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Table of Contents

VOL. 18 MARCH, 1935 No. 3

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The System Na_2O–B_2O_3, III. The Optical Properties, X-ray Patterns, and Melting Points of the Anhydrous Sodium Borates 79

By S. S. Cole, N. W. Taylor, and S. R. Scholes

The System Na_2O–B_2O_3, IV. Vapor Pressures of Boric Oxides, Sodium Metaborate, and Sodium Diborate between 1150°C and 1400°C 82

By S. S. Cole and N. W. Taylor

Comparison of Used Silica Brick from Insulated and Uninsulated Basic Open-Hearth Roofs 86

By F. A. Harvey

Reaction-Expansion Measurements on Chromite and Allied Spinels 94

By J. H. Chesters and C. W. Parmelee

Strength and Young's Modulus of Some Ground-Coat Enamels for Sheet Iron 100

By W. N. Harrison, S. M. Shelton, and W. H. Wadleigh

Analysis of Feldspar 106

By H. B. Knowles and J. C. Redmond

Ceramic Abstracts 59

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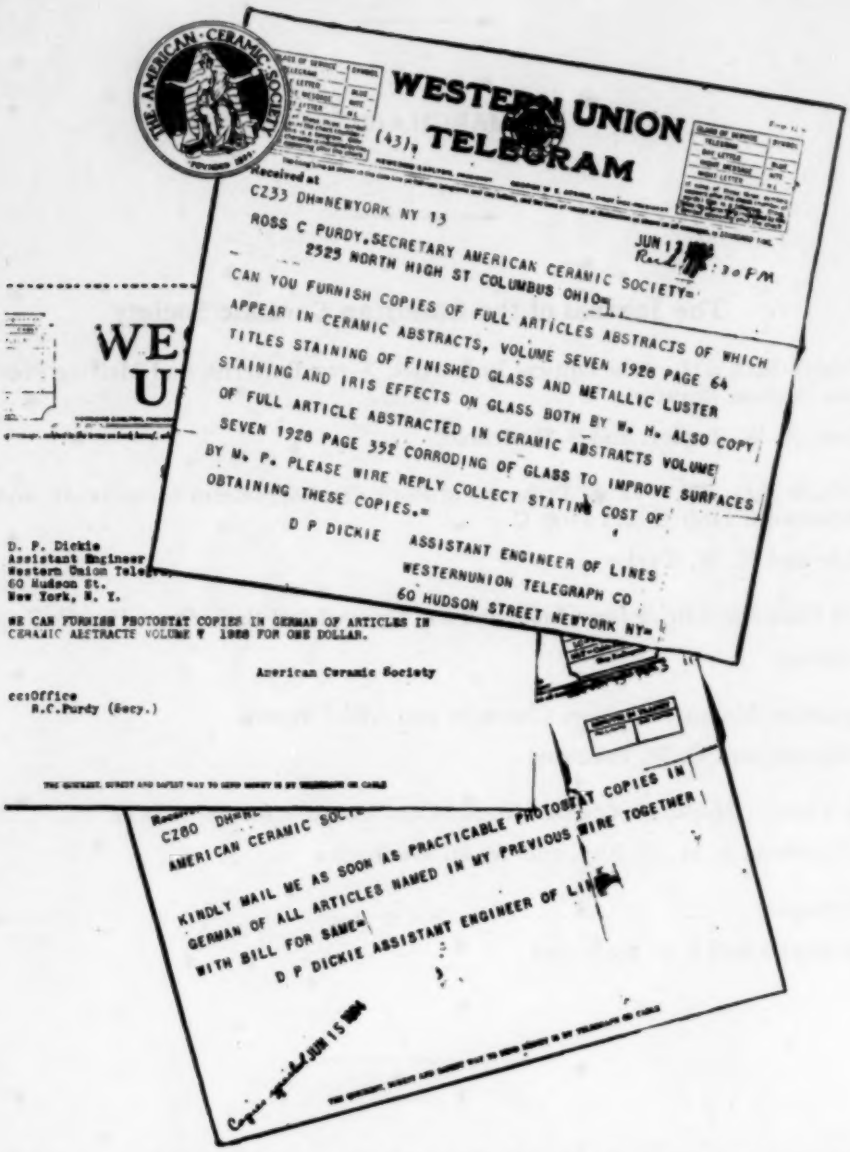
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THE SYSTEM Na_2O–B_2O_3, III

The Optical Properties, X-ray Patterns, and Melting Points of the Anhydrous Sodium Borates

By Sandford S. Cole, Nelson W. Taylor, and S. R. Scholes

Abstract

The sodium borates with the molecular ratio of Na_2O to B_2O_3 of 1:2, 1:3, and 1:4 have been crystallized. Optical properties, melting points, and X-ray diffraction data are reported.

I. Introduction

In connection with the study of vapor pressures of sodium borates reported in paper No. IV of this series,* the system sodium metaborate-boric oxide was investigated in order to determine what compounds exist and to have data on the melting points. One of these compounds has been reported in a previous paper.[1]

II. Historical

The available information on these materials was very scant.

Naumann,[2] Levy,[3] and Burgess and Holt[4] reported crystalline $Na_2O{\cdot}2B_2O_3$. Day and Allen[5] crystallized $Na_2O{\cdot}2B_2O_3$ and reported 742°C for the melting point, while Ponomareff[6] reported 732°C. The latter author made a complete study of the sodium borates and reported melting points of 694°C and 783°C for 1:3 and 1:4, respectively. Tammann[7] reported that 1:7 could be crystallized and had a melting point of 688°C. Randall, Rooksby, and Cooper[8] crystallized 1:2 and reported the "line spacing" of the material (probably *d*).

III. Method of Preparation and Testing

The glasses were prepared from sodium carbonate and boric oxide by melting molecular proportions in platinum. The final glass and crystals were analyzed for Na_2O content by titration with HCl $N/2$ with bromphenol blue as indicator.

The crystallization was from melts held at different temperatures until crystal growth would start. The temperature was raised until the crystals started to disappear and then was lowered about 20°C for large crystal growth to occur. At 670°C crystallization of the various compounds would proceed quite rapidly. Examination with the petrographic microscope was carried out after complete crystallization to determine if more than one crystal phase was present.

The melting points were determined by air-quenching the crystals after heating at various temperatures and determining the temperature at which the crystals changed into a glass. The indices of refraction were determined by oil immersion methods using standardized oils.

The X-ray data were obtained from films mounted in cameras having 57.65 millimeter radius using a Ksanda gas tube[9] with controlled leak and Cu target. Exposures of 6 hours at 25 KV and 10 ma. were made. All CuK_β lines were identified on the films by calculation. No filter was used.

Table I

Data Obtained

Compound	$Na_2O{\cdot}2B_2O_3$	$Na_2O{\cdot}3B_2O_3$	$Na_2O{\cdot}4B_2O_3$
Theoretical Na_2O (%)	31.0	22.7	18.3
Observed Na_2O (%)	30.8	22.8	18.2
Melting point (°C)	735°C ± 5	720°C ± 5	810°C ± 5
Crystal class*	Orthorhombic	Triclinic	Triclinic
Habit	Spherulitic needles	Tabular	Tabular
Index of Refraction			
N_p	1.515	1.518	1.505
N_m	1.535	1.530	1.525
N_g	1.570	1.583	1.594
Optical sign	Positive	Positive	Positive

* The crystal class may be in error although all are low symmetry.

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* This issue, p. 82.

[1] Sandford S. Cole, S. R. Scholes, and C. R. Amberg, "The System R_2O–B_2O_3, II. Properties of Anhydrous and Hydrated Metaborates of Sodium and Potassium," *Jour. Amer. Ceram. Soc.*, **18** [2], 58–60 (1935).

[2] C. F. Naumann, Lehrbuch der Krystallographie (1829).

[3] A. Levy, Description d'une Collection des Mineraux (1837).

[4] C. H. Burgess and A. Holt, *Proc. Roy. Soc.* [London], **74**, 285 (1904).

[5] A. L. Day and E. T. Allen, "The Isomorphism and Thermal Properties of the Feldspars," *Carnegie Inst. of Washington, Rept.*, No. 31 (1905).

[6] J. Ponomareff, "Acid Sodium Borates," *Z. anorg. Chem.*, **89**, 383–92 (1914); *Chem. Abs.*, **9**, 1435 (1915).

[7] G. Tammann (translated by R. F. Mehl), The States of Aggregation, pp. 233–36. D. Van Nostrand Co., New York, 1925.

[8] J. T. Randall, H. P. Rooksby, and B. S. Cooper, "X-ray Diffraction and the Structure of Vitreous Solids," *Z. Krist.*, **75**, 196–214 (1930).

[9] C. J. Ksanda, "A Metal X-Ray Tube for Characteristic Radiation," *Rev. Sci. Instruments*, **3** [10], 531–34(1932).

X-ray data are given in Tables II to IV, and the estimated intensities of the principal lines are given in Fig. 1. Because of the low symmetries, no attempt has been made to work out detailed structures.

TABLE II

X-RAY DIFFRACTION DATA ON $Na_2O \cdot 2B_2O_3$

$Na_2O \cdot 2B_2O_3$ on Cu wire (Camera radius 57.65 mm.) Cu rad. 25 KV 10 ma. 6 hr. λ for Cu K_α = 1.539 Å

Observed intensity	2L in 0.1 mm.	Calculated Cu lines	Corrected $Na_2O \cdot 2B_2O_3$	2θ	$\sin^2\theta$
2	200		200	19.88	0.0298
2	217		217	21.57	0.0350
1/2	252		252	25.05	0.0470
2	265		265	26.34	0.0519
2	281		281	27.93	0.0582
4	296		296	29.42	0.0645
1	316		316	31.41	0.0733
1	330		330	33.10	0.0812
1/2	348		348	34.59	0.0884
1/2	358		358	35.59	0.0934
1	374		374	37.17	0.1016
2	390	391			
1/2	398		398	39.56	0.1145
1/2	413		413	41.03	0.1228
1/2	427		427	42.42	0.1309
8	436	436			
1/2	446		446	44.31	0.1422
1	461		461	45.80	0.1500
1/2	481		481	47.79	0.1640
1	495		495	49.19	0.1731
4	507	508			
1	518		518	51.49	0.1887
1/2	538		538	53.47	0.2024
1/2	550		550	54.66	0.2108
1/2	558		558	55.46	0.2165
1/2	568		568	56.46	0.2237
1/2	582		582	57.84	0.2339
1/2	600		600	59.63	0.2472
1/2	617		617	61.33	0.2591
1/2	662	661			
1/2	686		686	68.19	0.3142
1/2	728		729	72.46	0.3493
4	745	746			
1/2	758		759	74.44	0.3659
1	780		781	77.62	0.3928
1	793	796			
1/2	810		812	80.70	0.4192
1/2	840		842	83.68	0.4450
1/2	860		862	85.67	0.4623
1/2	884		886	88.06	0.4831
10	902	905			
1/2	916		919	91.34	0.5117
1/2	940		943	93.72	0.5323
2	954	958			
1/2	985		988	98.20	0.5713
1/2	1012		1016	100.98	0.5952
1/2	1032		1036	102.97	0.6122
1/2	1077		1081	107.43	0.6498
1/2	1120		1129	112.21	0.6890
1	1145	1142			

IV. Discussion

Attempts to crystallize 1:5 yielded 1:4 and a glass. Melts of higher B_2O_3 content were not successfully crystallized but were very low melting glasses. Mixes of $3Na_2O \cdot 2B_2O_3$ gave Na_2CO_3 and $Na_2O \cdot B_2O_3$ when examined with the petrographic microscope. No attempt was made to determine the liquid-solidus boundary for any other compositions in the system.

The melting point of the 1:2 compound agreed well with published data, but the melting points of 1:3 and 1:4 are higher than those reported by Ponomareff and are more likely to be correct.

TABLE III

X-RAY DIFFRACTION DATA ON $Na_2O \cdot 3B_2O_3$

$Na_2O \cdot 3B_2O_3$ on Cu wire (Camera radius 57.65 mm.) Cu rad. 25 KV 10 ma. 6 hr. λ for Cu K_α = 1.539 Å

Observed intensity	2L in 0.1 mm.	Calculated Cu lines	Corrected $Na_2O \cdot 3B_2O_3$	2θ	$\sin^2\theta$
2	206		206	20.48	0.0314
1/2	220		220	21.86	0.0396
1	230		230	22.86	0.0393
2	244		244	24.25	0.0441
1/2	270		270	26.83	0.0539
1/2	285		285	28.33	0.0599
1/2	298		298	29.62	0.0663
2	306		306	30.42	0.0688
3	320		320	31.80	0.0751
1/2	335		335	33.30	0.0821
1	348		348	34.59	0.0884
1/2	372		372	36.97	0.1005
1	390	391			
1/2	417		417	41.43	0.1251
8	434	436			
1/2	442		444	44.11	0.1410
1	450	454			
1/2	465		467	46.40	0.1552
1	485		487	48.39	0.1680
8	506	508			
1/2	514		516	51.29	0.1873
1/2	526		528	52.48	0.1955
1/2	541		543	53.97	0.2059
1/2	559		561	55.76	0.2187
1/2	566		568	56.46	0.2237
1/2	592		594	59.04	0.2427
2	660	661			
1/2	676		678	67.39	0.3078
8	743	746			
1/2	778		781	77.62	0.3928
1	793	796			
1/2	812		815	81.00	0.4218
1/2	836		840	83.48	0.4432
1/2	855		860	85.47	0.4605
1/2	871		877	87.17	0.4753
8	899	905			
1/2	917		923	91.73	0.5151
1/2	936		943	93.72	0.5324
3	951	958			

Comparable indices of refraction of these compounds do not differ greatly. X-ray diffraction data show that these compounds are distinctly different and not a solid solution series as contended by some investigators. Line spacings reported by Randall for $Na_2O \cdot 2B_2O_3$ were 4.42 and 2.94 Å as compared with 4.46, 3.38, 3.19, 3.04, and 2.94 which were obtained as the principal lines in this work.

The series of sodium borate crystals of molecular compositions 1:1, 1:2, 1:3, and 1:4 form, with

crystalline B_2O_3, a series in which the atomic ratio of B/O has the successive values 1/2, 4/7, 6/10, 8/13, and 2/3, or 0.50, 0.57, 0.60, 0.62, and 0.67. The crystal structures appear to be hexagonal, orthorhombic, triclinic, triclinic, and cubic. In the silicates a variety of structures have been obtained, which, according to W. L. Bragg, depend primarily on the atomic ratio of Si/O. They are formed by linkage of SiO_4 tetrahedra into rings, chains, sheets, and three-dimensional networks, by joining at tetrahedral corners. In the borates, the fundamental unit of structure is a plane triangle of BO_3 ions with B in the center of three oxygen ions.[10] It will be interesting, when the structures of the above borates are worked out completely, to see how these triangles link together as the ratio B/O increases. The high birefringence of all the sodium borates is strong indication that all the BO_3 triangles lie in parallel planes in these crystals.

TABLE IV

X-RAY DIFFRACTION DATA ON $Na_2O{\cdot}4B_2O_3$

$Na_2O{\cdot}4B_2O_3$ on Cu wire — Cu rad. 25 KV 10 ma. 6 hr.
(Camera radius 57.65 mm.) — λ for Cu K_α = 1.539 Å

Observed intensity	2L in 0.1 mm.	Calculated Cu lines	Corrected $Na_2O{\cdot}4B_2O_3$	2θ	$\sin^2\theta$
½	152		152	15.11	0.0170
1	178		178	17.70	0.0239
2	196		196	19.48	0.0249
2	224		224	22.26	0.0374
2	242		242	24.05	0.0434
1	253		253	25.15	0.0474
5	265		265	26.34	0.0519
8	284		284	28.23	0.0595
6	299		299	29.72	0.0658
½	315		315	31.31	0.0728
½	331		330	32.80	0.0797
½	339		338	33.60	0.0835
½	357		356	35.39	0.0924
½	375		374	37.17	0.1016
½	385		384	38.17	0.1069
1	396	391			
1	406		405	40.25	0.1184
1	425		424	42.12	0.1291
8	437	436			
4	456		455	45.20	0.1477
½	469		469	46.60	0.1565
1	484		484	48.09	0.1660
2	495		497	49.39	0.1745
6	506	508			
1	526		528	52.48	0.1955
½	555		557	55.36	0.2158
½	579		581	57.74	0.2331
½	597		599	59.54	0.2465
½	622		624	62.02	0.2732
½	666	661			
½	680		682	67.79	0.3110
½	708		710	70.56	0.3336
4	744	746			
½	759		761	75.63	0.3759
½	795	796			
½	825		827	82.20	0.4321
½	843		845	83.98	0.4476
½	863		865	85.97	0.4649
½	887		890	88.45	0.4865
8	902	905			
½	915		918	91.24	0.5108
½	934		937	93.13	0.5273
2	955	958			
½	973		976	97.00	0.5609

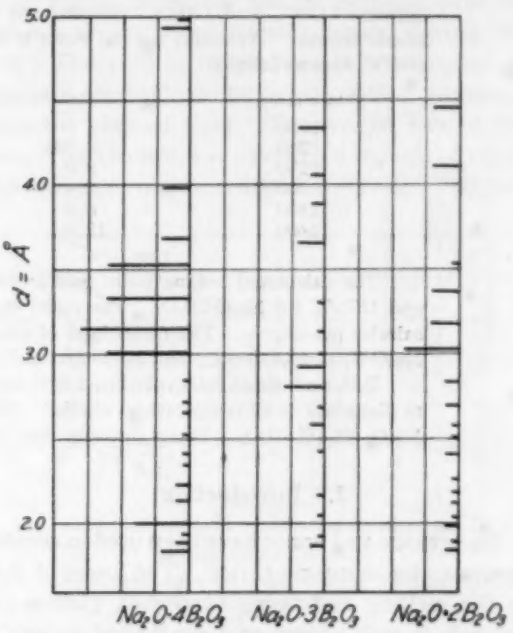

FIG. 1.—Estimated intensity of principal diffraction pattern lines.

V. Summary

Melting points, optical and crystallographic data, and X-ray patterns are recorded for $Na_2O{\cdot}2B_2O_3$ and $Na_2O{\cdot}3B_2O_3$ and $Na_2O{\cdot}4B_2O_3$ crystals.

Acknowledgment Grateful acknowledgment is hereby made for the coöperation at the Pennsylvania State College of Glenn Burgener in checking the indices of refraction and of Francis J. Williams on the X-ray data.

[10] W. H. Zachariasen, "The Structure of Groups XO_3 in Crystals," *Jour. Amer. Chem. Soc.*, 53, 2123 (1931).

THE SYSTEM Na_2O–B_2O_3, IV

Vapor Pressures of Boric Oxide, Sodium Metaborate, and Sodium Diborate between 1150°C and 1400°C

By Sandford S. Cole and Nelson W. Taylor

Abstract

Vapor pressures of B_2O_3, $Na_2O \cdot B_2O_3$, and $Na_2O \cdot 2B_2O_3$ were obtained at 50°C intervals between 1150°C and 1400°C, utilizing the dynamic method with dry N_2 under normal atmospheric pressure. Assuming normal vapor densities, the vapor pressures in millimeters of mercury at 0°C were as follows:

Temperature, °C	B_2O_3	$Na_2O \cdot B_2O_3$	$Na_2O \cdot 2B_2O_3$
1150		2.55	2.1
1200	0.83	7.2	5.5
1250	2.0	28.0	13.0
1300	3.4	62.0	25.5
1350	6.9	160.0	
1400	12.0		

The calculated boiling point was found to be 1860°C for B_2O_3, 1434°C for $Na_2O \cdot B_2O_3$, and 1575°C for $Na_2O \cdot 2B_2O_3$. The molal entropy of vaporization of B_2O_3 was found to be 32.2 calories per degree. The molal heat of vaporization was calculated to be B_2O_3, 65,600 cal.; $Na_2O \cdot B_2O_3$, 96,910 cal.; and $Na_2O \cdot 2B_2O_3$, 72,410 cal.

B_2O_3 and $Na_2O \cdot B_2O_3$ volatilized without change in composition, but $Na_2O \cdot 2B_2O_3$ was found to dissociate at all temperatures studied. It yielded a vapor of calculated composition 51.6% Na_2O, 48.4% B_2O_3. Vapor pressure data based on this composition are also reported.

I. Introduction

Boric oxide and borax have been used in ceramic processes for many centuries. The losses of B_2O_3 in the melting and fining of glasses, glazes, and enamels is well known and recognized as one of the problems in the use of these materials. The conditions which cause these losses have been attributed to the volatilization of the B_2O_3 as a hydrate during the dehydration of the boric acid or borax. No information of any consequence has been available as to the vapor pressure of sodium borates or boric acid in molten condition at elevated temperatures. The study of the vapor pressure of these materials provides data concerning the individual materials and will perhaps serve as an aid in the study of boric oxide losses.

II. Historical

The only information on the vapor pressure of $Na_2O \cdot 2B_2O_3$ was by Kolthoff[1] who found little volatilization at 880 to 940°C in a covered crucible. Briscoe and Robinson[2] claimed that $Na_2O \cdot 2B_2O_3$ dissociated, losing Na_2O. Van Klooster[3] and Jaeger[4] reported that $Na_2O \cdot B_2O_3$ started to volatilize at 1230°C and volatilized rapidly at 1350°C.

Mott[5] gave 760 millimeters for the vapor pressure of B_2O_3 at 1500°C, while von Wartenberg and Bosse[6] reported 138 millimeters at 1501°C.

III. Method of Determination

The materials used were prepared as described in paper III of this series.* The vapor pressures were obtained from the weight loss of a sample subjected to a stream of inert gas which passed over the material at a given velocity. The rate of flow was varied so that a series of determinations were obtained at a given temperature. The apparent vapor pressures are a linear function of the rate of gas flow, so that the data can be extrapolated to zero flow of gas to give the vapor pressure at the temperature of the test.

[1] I. M. Kolthoff, "Volatility of Borax," *Nature*, **119**, 427 (1927).

[2] H. V. A. Briscoe and P. L. Robinson, "Volatility and Dissociation of Borax," *ibid.*, **118**, 374 (1926).

[3] H. S. Van Klooster, "Behavior of Metaborate and Metaphosphoric Acids in Melts of Their Alkali Salts," *Z. anorg. Chem.*, **69**, 122–34 (1911).

[4] F. M. Jaeger, "The Temperature Lowering of Surface Tension of Liquids in the Temperature Range of −80 to 1650°C," *Z. anorg. Chem.*, **101**, 1–214 (1917).

[5] W. R. Mott, "Relative Volatilities of Refractory Materials," *Trans. Amer. Electrochem. Soc.*, **34**, 255–95 (1918).

[6] H. von Wartenberg and O. Bosse, "Vapor Pressure of Some Salts," *Zeit. Chem. Apparatenkunde*, **28**, 384 (1922).

* See this issue p. 79.

The apparatus is shown in Fig. 1. The nitrogen (CO_2 free) was passed over heated Cu gauze to remove any O_2 and then over barium perchlorate to remove moisture. The sample was contained in a platinum bucket suspended in the middle section of an electric resistance furnace. Both Mo-wound and Pt-Rh wound furnaces were used. The gas and vapor then passed through calcium

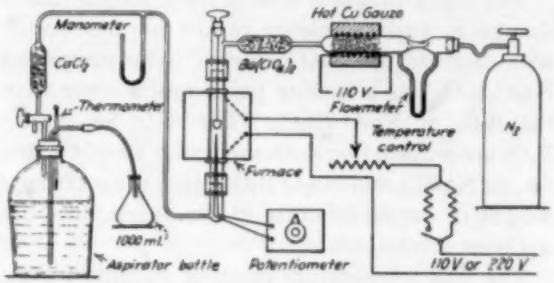

FIG. 1.—General arrangement of vapor-pressure apparatus (not to scale).

chloride which was used to prevent back-diffusion of water vapor. The gas was collected over water, and the volume was measured by the displaced water.

The temperature was controlled by the use of a suspension galvanometer connected in parallel with the potentiometer galvanometer. The galvanometer mirror acted as an optical lever which actuated a photoelectric cell relay whereby the current was increased or decreased. The wiring

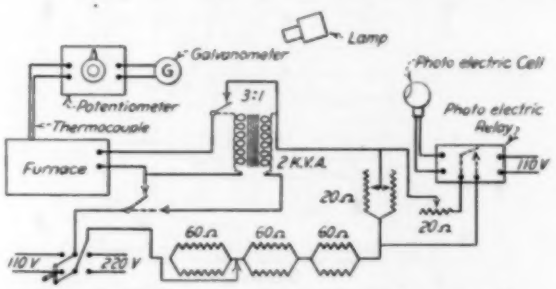

FIG. 2.—Wiring diagram for temperature control.

diagrams are shown by Fig. 2. The temperature could be maintained within 1°C at the junction of the thermocouple; the entire bucket was within 1 centimeter of the junction so that the sample was not subjected to any noticeable variation in temperature. The thermocouple was checked against a thermocouple which had been calibrated at the Bureau of Standards and was found to agree to within 1°C in the temperature range of the tests.

The vaporization chamber was lined with a platinum shield in order to prevent the vapor from collecting on the mullite tube and thereby causing errors in the determinations. The barometric pressure varied less than 0.3 millimeter mercury in any determination so the error due to the barometric variation was less than 0.5%.

The normal procedure was to collect a liter of water and to determine the temperature over the water and the barometric pressure during the test. The volume of gas was then corrected to standard conditions and the rate of flow calculated from the elapsed time. The weight loss of the sample for the test was calculated to mols of vapor and the gas volume reduced to mols. The mol

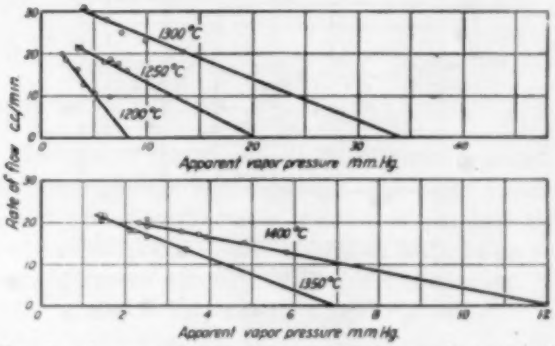

FIG. 3.—Apparent vapor pressure of B_2O_3, varying rates of flow and temperature.

fraction multiplied by the barometric pressure gave the apparent vapor pressure. The calculations were as follows:

$$V_o \times \frac{P - p'}{760} \times \frac{273}{273 + t} = V_s$$

$$\frac{L/M}{V_s/22.4 + L/M} \times P = AVP$$

Where V_o = vol. H_2O collected.
V_s = vol. of N_2 gas under standard conditions.
P = barometric pressure.
p' = partial pressure of water at temperature, t.
L = weight loss of sample.
M = molecular weight of sample.
AVP = apparent vapor pressure.

The heat of vaporization and boiling point were then calculated from the Clapeyron equation $\log p_2/p_1 = \Delta H(1/T_1 - 1/T_2)/2.303R$. The entropy of vaporization was obtained according to Hildebrand[7] by the relation $\Delta H/T_c = \Delta S$ at a concentration of 0.00507 mol/liter. T_c is the point of intercept of the straight line $\log p = \log T - 0.5$ with the $\log p$ *vs.* $\log T$ curve.

[7] J. H. Hildebrand, Solubility, pp. 93–95. The Chemical Catalog Co., New York (1924).

The determination of the composition of the residual borates after volatilization losses was considered important. Sodium silicates show a relative loss in Na_2O on heating to high temperatures, so after each run the borate was analyzed for Na_2O by titrating with 0.5 *N* HCl against bromphenol blue as indicator.

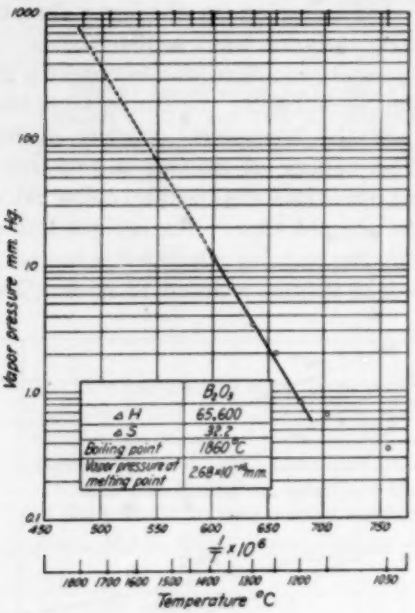

FIG. 4.—Vapor pressure *vs.* $1/T$ of B_2O_3.

The Na_2O content is given in Table II.

TABLE II

Na_2O Content of Liquid Phase.

	Original	After heating at 1150°C	1200°C	1250°C	1300°C
$Na_2O \cdot B_2O_3$	47.0%	46.9%	46.8%	46.9%	46.8%
$Na_2O \cdot 2B_2O_3$	30.9%	30.0%	30.0%	28.9%	28.9%

In order to ascertain the vapor composition in the case of the $Na_2O \cdot 2B_2O_3$, the loss in weight of the sample was determined and the amount of Na_2O in the vapor was calculated. The data are given in Table III.

TABLE III

COMPOSITION CHANGES IN $Na_2O \cdot 2B_2O_3$

	Unheated	1150°C	1200°C	1250°C	1300°C		
Na_2O (%)	30.9	30.0	30.0	28.9	29.0	28.9	28.1
Loss (%)		3.79	3.73	6.3	8.5	8.7	12.1
Na_2O in vapor (%)		52.7	51.4	50.9	51.8	51.7	51.3

Average composition of vapor { 51.6% Na_2O / 48.4% B_2O_3

If volatilizing as Na_2O and $Na_2O \cdot 2B_2O_3$, the vapor composition would be { 30.1% Na_2O / 69.9% $Na_2O \cdot 2B_2O_3$; mean mol. wt. 158.3

IV. Data Obtained

Although nearly 400 determinations were made, the only data which will be reported are the final values and a few curves to show a typical case.

The final values are given in Table IV and the curves are shown in Figs. 3 to 6.

V. Discussion

The vapor-pressure studies have shown that a change in vapor pressure of the borates occurs with increase in Na_2O content. The compound $Na_2O \cdot B_2O_3$ has a boiling point much lower than the B_2O_3 or $Na_2O \cdot 2B_2O_3$. The data for $Na_2O \cdot B_2O_3$ are reported on both molecular weight bases, *i.e.*, as $NaBO_2$ and $Na_2O \cdot B_2O_3$, since the molecular weight of the metaborate in the vapor state has not been determined.

The long temperature range of stability for the liquid phase of B_2O_3 (from melting point 294°C to boiling point 1860°C) is rather interesting. All B_2O_3 samples as well as the borates were dehydrated before obtaining the vapor pressure data. The dehydration was carried out above 1500°C for B_2O_3 and above 1400°C for the borates, using an oxygen-gas flame for the source of heat. The borates generally boiled during the dehydration. Previous values for the vapor pressure of B_2O_3 may have been affected by moisture combined with or held by the B_2O_3 glass.

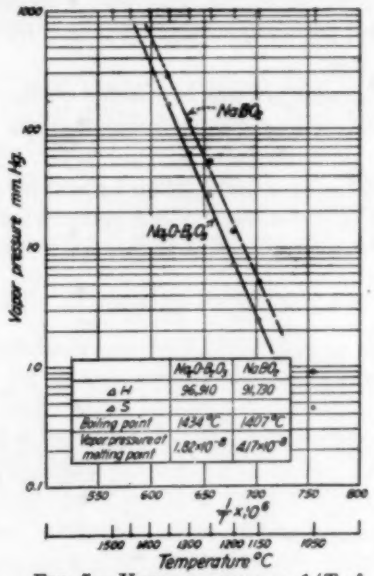

FIG. 5.—Vapor pressure *vs.* $1/T$ of $Na_2O \cdot B_2O_3$ and $NaBO_2$. S values to be obtained from table IV.

The molal entropy of vaporization of B_2O_3 is 32.2, which agrees with data on polar liquids like H_2O(32.0) or CH_3OH (33.4) as contrasted with a mean value of 27.4 for normal liquids.

The polar characteristics of boric oxide are quite apparent from the number of borates found as natural minerals. The high entropy of vaporization of sodium metaborate would indicate that it is a strongly ionized salt.

The writers are well aware of the fact that the dynamic method can not be relied upon to give true vapor pressures in the absence of any sure knowledge of the molecular formula for the gas molecules in the case of $NaBO_2$ and of a simple and partially dissociated molecule in the case of $Na_2O{\cdot}3B_2O_3$. The assumption of simple molecules is felt to be most certain in the case of B_2O_3, since the molal entropy of vaporization agrees well with that of H_2O despite the wide difference in their boiling points. Nevertheless, vapor-density determinations at temperatures above 1000°C are highly desirable.

TABLE IV

VAPOR PRESSURES OF B_2O_3, $Na_2O{\cdot}B_2O_3$, $Na_2O{\cdot}2B_2O_3$ (in mm. Hg at 0°C)

Temperature (°C)	B_2O_3	$Na_2O{\cdot}B_2O_3$	$NaBO_2$	$Na_2O{\cdot}2B_2O_3$	Vapor M. W. 158.3
1150		2.55	5.1	2.1	2.5
1200	0.83	7.2	14.0	5.5	7.0
1250	2.0	28.0	53.0	13.0	17.0
1300	3.4	62.0	120.0	25.5	31.5
1350	6.9	160.0	280.0		
1400	12.0				
Boiling point (calculated)	1860°C	1434°C	1407°C	1575°C	1540°C
Heat of vaporization (cal./mol.)	65,600	96,910	91,730	72,410	75,190
Molal entropy of vaporization (cal./deg.)	32.2	57.8	55.3	40.6	42.7
Vapor pressure at melting point in mm. Hg (calculated)	2.68×10^{-16}	1.82×10^{-8}	4.17×10^{-8}	5.87×10^{-6}	4.40×10^{-6}

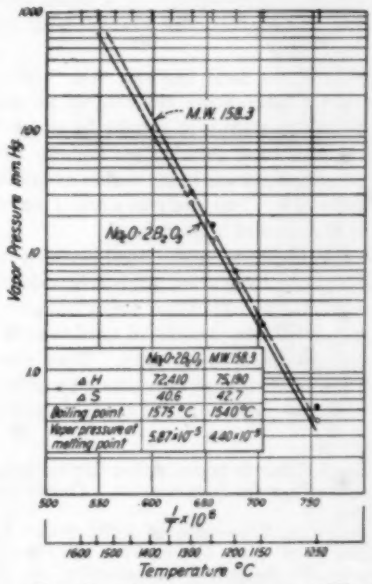

FIG. 6.—Vapor pressure *vs.* $1/T$ of $Na_2O{\cdot}2B_2O_3$ and of vapor-molecular weight 158.3.

In view of the large boric oxide losses reported by glass melters it is probable that water vapor plays an important rôle, and it is planned to continue vapor-pressure studies on B_2O_3 in presence of known partial pressures of water vapor.

VI. Summary

Vapor pressures of B_2O_3, $Na_2O{\cdot}B_2O_3$, and $Na_2O{\cdot}B_2O_3$ were obtained at 50°C intervals between 1150°C and 1400°C, utilizing the dynamic method with dry N_2 under normal atmospheric pressure. Assuming normal vapor densities the vapor pressures in millimeters of mercury at 0°C were as follows:

Temperature (°C)	B_2O_3	$Na_2O{\cdot}B_2O_3$	$NaO{\cdot}2B_2O_3$
1150	*	2.55	2.1
1200	.83	7.2	5.5
1250	2.0	28.0	13.0
1300	3.4	62.0	25.5
1350	6.9	160.0	
1400	12.0		

The calculated boiling point was found to be 1860°C for B_2O_3, 1434°C for $Na_2O{\cdot}B_2O_3$, and 1575°C for $Na_2O{\cdot}2B_2O_3$. The molal entropy of vaporization of B_2O_3 was found to be 32.2 calories per degree. The molal heat of vaporization was calculated to be B_2O_3, 65,600 cal.; $Na_2O{\cdot}B_2O_3$, 96,910 cal.; and $Na_2O{\cdot}2B_2O_3$, 72,410 cal. B_2O_3 and $Na_2O{\cdot}B_2O_3$ volatilized without change in composition but $Na_2O{\cdot}2B_2O_3$ was found to dissociate at all temperatures studied. It yielded a vapor of calculated composition 51.6% Na_2O, 48.4% B_2O_3. Vapor pressure data based on this composition are also reported.

COMPARISON OF USED SILICA BRICK FROM INSULATED AND UNINSULATED BASIC OPEN-HEARTH ROOFS*

By Fred A. Harvey

Abstract

Samples of silica brick from the roofs of two basic open-hearth furnaces, one of which had been insulated and the other uninsulated, after a full campaign were compared chemically and petrographically. The uninsulated brick was divided into nine distinct color zones, while the insulated brick showed but three. The three zones of the insulated brick were nearly identical zone for zone with the three inner zones of the uninsulated brick. The zone of weakness which normally occurs in open-hearth roof brick from uninsulated furnaces did not occur in the brick from the insulated roof. Chemical and petrographic analyses are given.

I. Introduction

Within the last year or two, the practice of insulating open-hearth furnaces has shown rapid increase. Recently two samples of silica brick were obtained which had each been through a campaign in the roof of a basic open-hearth furnace in a large steel plant in the Calumet District. One sample came from a furnace having an insulated roof which had lasted 364 heats, the other from an uninsulated roof of a furnace of the same type which had lasted 346 heats. Reports on silica brick from uninsulated furnaces have previously been published, but so far as the writer is aware, brick from an insulated furnace roof have not previously been studied.

Literature

A brief review of the literature covering silica brick from uninsulated open-hearth, furnaces follows.

Endell[1] describes the crystalline structure of silica brick taken from a Siemens-Martin (open-hearth) furnace after 10 and 50 heats and also the crystalline composition of a brick which showed three zones of distinct character. The inner, hot, zone had become plastic and the silica was completely converted to cristobalite. The middle zone consisted largely of tridymite with a portion of "amorphous quartz" which was probably cristobalite (see pp. 602 and 820 of the work cited in footnote 12). The third, coolest, zone was practically unchanged from the original fired brick.

Le Chatelier[2] states that in steel furnaces, where the temperature is higher than 1480°C, silica brick are transformed wholly into tridymite. He concludes that Fenner's[3] statement that tridymite is the stable form from 870 to 1470°C and cristobalite above this temperature is not established. Fenner's temperature limits have since been confirmed and are now generally accepted.

Rengade[4] is quoted by Rochow[5] and McDowell.[6] Four distinct zones are distinguished and the absorption of iron oxide and lime from the dust-laden gases is established. It is also shown that iron and lime migrate from the hot end toward the cool end, the lime migrating the greater distance.

Nesbitt and Bell[7] show the per cent silica, iron oxide, and lime of a used silica brick at six points varying in distance from the hot end. The large increase in iron oxide, from 1 to 14%, and the increase and migration of lime in basic open-hearth furnace brick are evident.

Williams[8] shows a photograph of a brick taken from an open-hearth roof after 125 heats. Four zones are evident.

Rees[9] gives the chemical analysis and "refractoriness cone" for a brick taken from the roof of an acid and a basic open-hearth furnace. It should be noted that the point where the lime and alumina are highest corresponds with cones 27 and 28 which is the region of lowest refractoriness in the series. The analyses show a concentration of alumina in the zone of highest lime.

Probably the most complete study which has been reported was made by Larsen and Schroeder.[10] These authors divided the brick into four zones and give chemical analyses and petrographic studies of used brick from both basic and acid open-hearth furnaces. They show cristobalite to be the predominant crystalline form for the hot end of the brick for both types of furnaces and show the

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* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Refractories Division). Received November 30, 1934.

[1] K. Endell, "Über die Konstitution der Dinasteine," *Stahl u. Eisen*, **32**, 392–97 (1912).

[2] H. LeChatelier, "Les Briques de Silice," *Rév. Mét.*, **14** [2] 73–83 (1917); also *Bull. soc. franç. minéral.*, **40**, 44–47 (1917).

[3] C. N. Fenner, "The Relations between Tridymite and Cristobalite," *Jour. Soc. Glass Tech.*, **3**, 116–25 (1919).

[4] E. Rengade, "Sur la composition des briques de silice provenant des voutes de dour martin," *Compt. rend.*, **166**, 779–81 (1918).

[5] W. F. Rochow, "Selection of Refractories for Industrial Furnaces," *Ind. Eng. Chem.*, **11**, 1146 (1919).

[6] J. Spotts McDowell, "Refractories in the Steel Industry," *Blast Fur. Steel Plant*, **11**, [11–12], 525, 569 (1923).

[7] C. E. Nesbitt and M. L. Bell, "Effect of Heat on Refractories," *Iron Trade Rev.*, **65**, 1112–14 (1919).

[8] C. E. Williams, "Operating Conditions in the Open Hearth as They Affect Refractories," *Jour. Amer. Ceram. Soc.*, **7** [9], 681–86 (1924).

[9] W. J. Rees, "The Changes Which Take Place in Silica Brick during Their Use in Open-Hearth Furnaces," *ibid.*, **8** [1], 40–42 (1925).

[10] B. M. Larsen and F. W. Schroeder, "Service Conditions of Refractories for Open-Hearth Steel Furnaces," *Carnegie Inst. Tech. Bull.*, No. 23, 122 pp. (1925).

FIG. 2.

migration of the iron, lime, and to some extent the alumina, toward the cooler zones. This report contains an excellent bibliography.

Clark and Anderson[11] studied the X-Ray diffraction patterns for pure quartz, ganister, fired silica brick, and the various zones of silica brick after service in an open-hearth furnace.

The various crystal modifications of silica and the

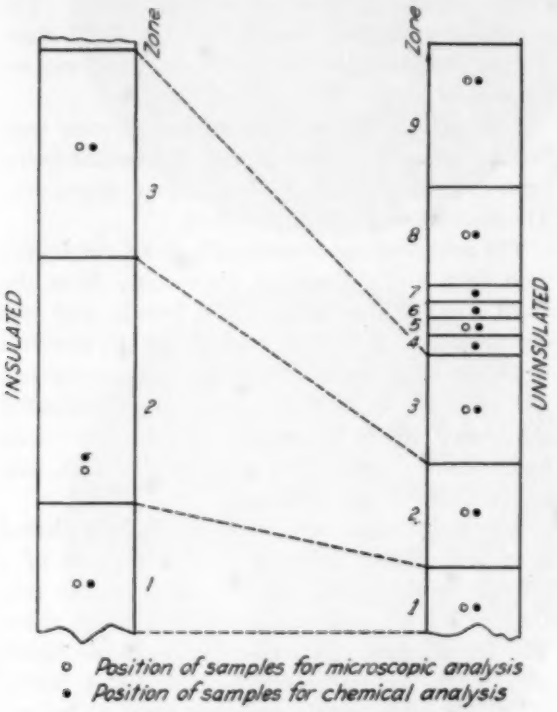


FIG. 1.—Silica brick from basic open-hearth roof.

temperatures at which they occur are discussed exhaustively by R. B. Sosman.[12]

II. Description of Samples

(1) General The brick which were studied were made from Baraboo quartzite with 2% added lime. As originally installed they were 12- by 4½- by 3-inch wedge brick. They were made by the power-press process and probably had a porosity of about 25% and an apparent specific gravity of 2.35. The two brick tested were reported to be typical of the rest of the roof.

Each of the two brick was sawed lengthwise into four approximately equal parts. One piece of each brick was used for chemical analysis and one of each for microscopic examination. Samples for chemical analysis were taken at the points marked with heavy dots, those for microscopic examination at the points marked with circles, as is shown in Fig. 1. The appearance of the sawed sections is shown in the colored insert, Fig. 2.

The lower or hot end of the brick appeared to

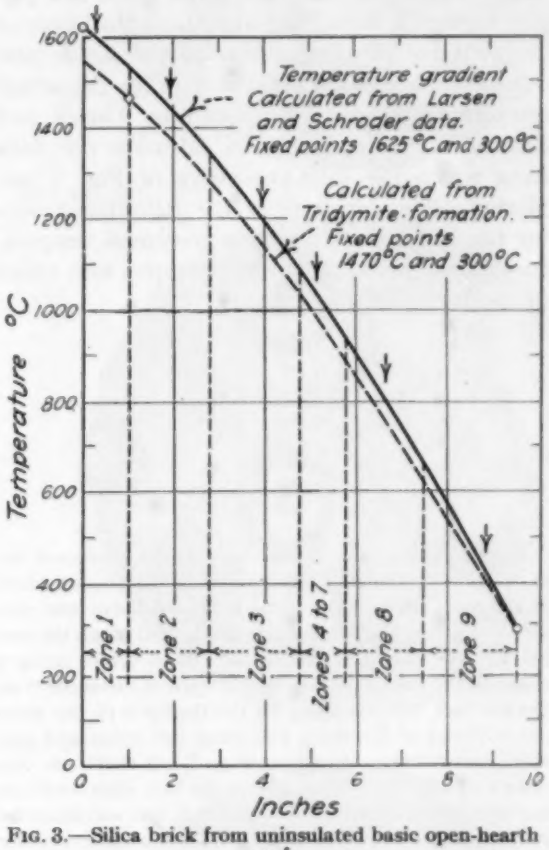


FIG. 3.—Silica brick from uninsulated basic open-hearth roof.

have fluxed and slowly dripped away. It showed no evidence of the deep pitting and holes which accompany excessive overheating. (Of course, the long roof life is the best evidence that the roof was not overheated.) According to Larsen and Schroeder,[10] the average maximum temperature of the hot surface of the roof brick in a well-operated basic open-hearth furnace reached 1600 to 1625°C (about 2900 to 2950°F) just before tapping. At temperatures in excess of 1650°C the brick were "burned" and deteriorated rapidly. It seems reasonable to assume that the hot face of the brick used in this investigation reached a

[11] G. L. Clark and H. V. Anderson, "X-Ray Study of Zonal Structure of Silica Brick from the Roof of a Basic Open-Hearth Furnace," *Ind. Eng. Chem.*, 21 [8], 781–85 (1929).

[12] R. B. Sosman, The Properties of Silica. The Chemical Catalog Co., 1927.

temperature of about 1625°C but was probably not much hotter than this for any considerable period of time. The temperature of the outside surface of the uninsulated roof can not be as closely fixed. References to Larsen and Schroeder indicate considerable variation between furnaces. It appears reasonable to assume an average temperature of 300°C (572°F) for the cooler end of the brick. It would doubtless have been cooler than 350°C when the furnace was first put into operation with the full 12-inch thickness of roof. With the temperature of the inside and outside surfaces fixed and the data for the actual temperature gradient measured by Larsen and Schroeder, it is possible to calculate the data from which the solid-line curve of Fig. 3 was plotted. This chart gives the following figures for the approximate average maximum temperature for the points from which samples were taken for petrographic analysis.

TABLE I

(Zone)	(°C)	(°F)
1	1600	2912
2	1440	2624
3	1200	2192
5	1025	1877
8	800	1472
9	400	752

NOTE: Larsen and Schroeder actually measured the temperature gradient by means of thermocouples imbedded in the roof. From their tests, a typical curve was constructed giving the temperature gradient through the roof brick. The curves of Fig. 3 were then drawn using a curve of the same relative slope at various distances from the hot face, but correcting for the thickness of the uninsulated brick of this study and using the inside and outside temperatures shown in Fig. 3. A chart was also drawn which was calculated from the best data available for thermal conductivity of silica brick, but was discarded in favor of the experimental data of Larsen and Schroeder, since available data apply only to unaltered silica brick and the conductivity would be expected to be different after the brick had suffered the radical changes which this paper describes. The chart calculated from conductivity data did not, however, differ radically from Fig. 3.

(2) Visual Inspection

(*a*) Uninsulated Brick The brick from the uninsulated roof presented the typical appearance of a silica brick which has been through an open-hearth campaign. About nine and one-half inches of the original twelve-inch brick remained. The zones were numbered from one to nine starting at the inside hot end.

The first zone (hot end) consisted of about one inch which was uniformly dense and of a light slate gray color. No trace of the original brick structure remained. The plane of separation between the first and second zones was quite distinct. The temperature at this plane is estimated as about 1540°C (2804°F).

The second zone was dense and dark gray in color and about $1\frac{3}{4}$ inches deep. Practically no trace of the original brick structure was visible. The second zone shaded sharply into the third zone. The temperature at the boundary plane was estimated at about 1350°C (2462°F).

The third zone was a greenish-gray color containing numerous white grains, the largest being from $\frac{1}{16}$ to $\frac{1}{8}$ inch in the largest dimension. The zone was about 2 inches deep.

The next four zones were each about one-fourth inch deep and differed in appearance from the third zone only in color. The fourth zone was cream colored, the fifth was of a light purplish tinge, the sixth was yellow-cream, and the seventh was of a dark purplish color. It is estimated that the outside boundaries of the four zones had been at average temperatures of 1075°C and 925°C (1967°F and 1697°F).

The eighth zone appeared but slightly altered from the original brick structure but was of a reddish-brown color. It shaded gradually into the ninth zone and was about $1\frac{3}{4}$ inches thick. The temperature of the plane between the eighth and ninth zone is estimated at about 650°C (1202°F). The ninth zone appeared to be unaltered brick.

(*b*) Insulated Brick The brick from the insulated roof was about nine inches long and was divided into three distinct zones.

The insulation used on the roof consisted of three inches of expanded vermiculite granules and one inch of vermiculite plaster.

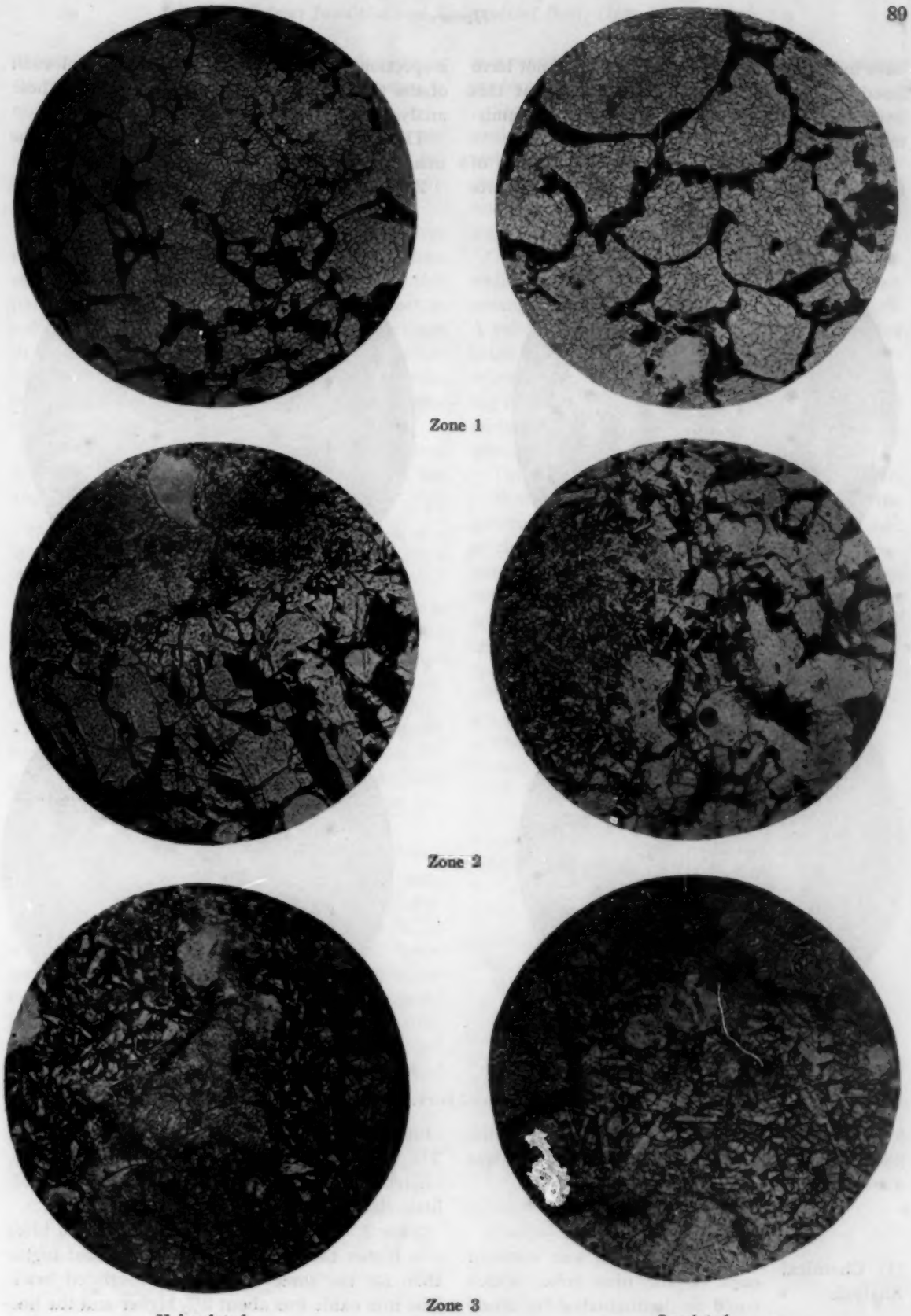
The first zone was about two inches deep and corresponded exactly in appearance to zone 1 of the uninsulated brick.

The second zone appeared identical in appearance with zone 2 of the uninsulated brick. It was about four inches deep.

The third zone, again, was of identical appearance with zone 3 of the uninsulated brick.

There were no zones corresponding to zones 4 to 9 of the uninsulated brick.

The insulation had fused to the brick at the contact face and a layer about $\frac{1}{8}$ inch thick was still adhering to the brick. Laboratory tests



Zone 1

Zone 2

Zone 3

Uninsulated Insulated

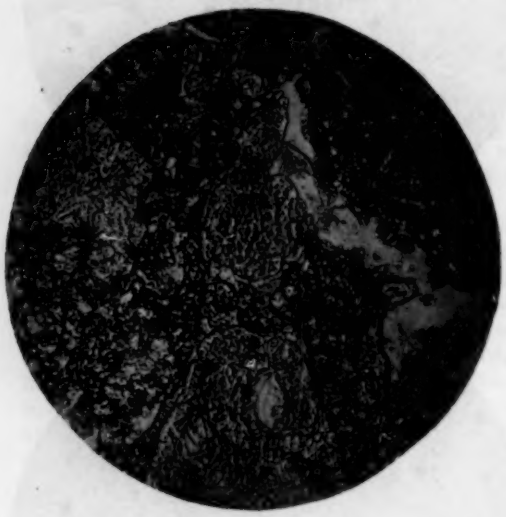
FIG. 4.—Photomicrographs of uninsulated and insulated brick showing zones 1, 2, and 3. Magnification approximately 70 × natural light.

have indicated that the insulation should not have fused at the temperature which existed at this inner face, yet the evidence of fusion was unmistakable.

Based on the condition of the three zones of the insulated brick and the temperature estimate for the uninsulated brick, the temperature at the plane of contact between brick and insulation was about 1040 to 1150°C (1904 to 2102°F).

Zone 5. Natural light.

Zone 8. Natural light.



Zone 9. Natural light.

Zone 9. Crossed-nicols.

FIG. 5.—Photomicrographs of uninsulated brick. Magnification approximately 70 ×.

III. Tests

(1) Chemical Analysis

Chemical analysis was made of each of the nine zones which could be distinguished by visual inspection of the uninsulated brick and of each of the three zones of the insulated brick. These analyses are given in Table I.

The chemical analysis of zone 9 represents the unaltered brick.

Zone 1: The analysis of zone 1 was nearly the same for both insulated and uninsulated brick. The iron oxide was higher than zone 9 (the unaltered zone) by about 6%. There was relatively little change in the other constituents.

Zone 2: The alumina in the uninsulated brick was higher than the original amount and higher than for the same zone in the insulated brick. The iron oxide was about 2% higher and the lime

about 1% higher in the insulated brick than in the uninsulated brick. The silica was correspondingly lower for the insulated brick.

Zone 3: This zone showed nearly the same analysis in both insulated and uninsulated brick except that the alumina was higher in the uninsulated specimen.

Zones 4 to 7 (inclusive): These zones have commonly been grouped together in previous studies of brick from open-hearth roofs. In this particular study, the bands were very distinct in color. The analyses showed a gradual decrease in iron oxide and lime. These zones are commonly recognized as a region of mechanical weakness. It is noteworthy that this region does not exist in the insulated roof.

Zones 8 and 9: These zones are practically identical in analysis and as stated above give the analysis of the original brick.

Note: The petrographic examinations have been made by C. R. Fettke, Carnegie Institute of Technology, Pittsburgh, Pa.

(2) Petrographic Examination

(*a*) Uninsulated Brick

Section from Zone 1: Zone 1 represents the lower one-inch band, that portion which was directly exposed to the heat, gases, vapors, and dust. The outlines of the original ganister particles have practically disappeared. Patches of finer-grained material with smaller amounts of silicates and iron-oxide dendrites mark their former position.

The section is made up of an interlocking mosaic of partially rounded cristobalite grains averaging about 0.15 millimeter in diameter. Each of these grains is composed of a great number of small individual interlocking cristobalite units 0.02 millimeter and less in diameter. Considerable quantities of black opaque iron-oxide dendrites occur between the cristobalite grains. Associated with these dendrites there is a small quantity of a rich yellowish-brown crystalline silicate. On account of the feathery nature and the minute size of the individual units, it is difficult to identify this silicate positively but it is thought that it represents a lime-iron olivine, perhaps approaching fayalite in composition. The lower one-inch zone consists predominantly of cristobalite.

Note: From physicochemical data, R. E. Birch believes that a pyroxene is more to be expected than an olivine. Dr. Fettke mentioned olivine because the index of refraction was higher than for pyroxene. The presence of the iron oxide complicates the situation, since its presence increases the value of the refractive index for olivine as well as pyroxene.

Section from Zone 2: The outlines of original ganister particles have almost disappeared. No residual quartz remains. The still recognizable ganister particles consist of an outer rim of small interlocking tridymite crystals usually enveloping a small cristobalite nucleus.

The main portion of the section consists of well-developed interlocking tridymite crystals averaging 0.25 by 0.04 millimeter in cross-section. A yellowish-green glass with abundant embedded black opaque iron-oxide dendrites fills the interstices between the tridymite crystals. The striking features of this section are the well-developed tridymite crystals with sharp boundaries and the abundant iron-oxide dendrites between them.

This zone consists predominantly of tridymite.

Section of Zone 3: This section represents the outermost portion of the appreciably altered part of the sample of uninsulated brick. The coarser ganister particles are still recognizable in this section but their boundaries have become ragged due to conversion into tridymite around their peripheries. Many of the smaller ones have disappeared completely. A little residual quartz is still present in the larger grains. They still consist predominantly of cristobalite.

The matrix consists of well-developed tridymite crystals ranging in cross-section from 0.03 by 0.015 millimeter to 0.08 by 0.04 millimeter. A yellowish-green glass fills interstices between the tridymite crystals. Glass is present in appreciably larger quantities than in sections 5, 8, and 9. In irregular-shaped patches dark reddish-brown almost opaque dendrites, probably representing ferric oxide, are embedded in the glass. Such patches are not abundant, however.

Section of Zone 5: Section 5 came from the midst of a zone of alternating white, buff, and pink-colored bands which, with the exception of color, do not appear to have been greatly altered from their original condition. The outlines of the coarser ganister particles are still readily distinguishable from the matrix and the amount of residual quartz in them has not been appreciably reduced. They consist predominantly of cristobalite.

Tridymite development in the matrix has proceeded a little further than in section 8, the interlocking tridymite crystals possessing average cross-sections of about 0.04 by 0.01 millimeter.

The small amounts of glass between the tridymite crystals in that portion of the section representing the narrow band with a pinkish cast possesses a pale yellowish-brown color.

Section of Zone 8: The outlines of the coarser ganister particles are still readily distinguishable from the matrix in this section. The larger ones contain about the same amount of residual quartz as those of section 9 and consist predominantly of cristobalite. Tridymite was not definitely identified in them.

The matrix of section 8 possesses a better tridymite development than that of section 9. The minute interlocking tridymite crystals possess average cross-sections of 0.037 by 0.01 millimeter. The small amount of glass between the tridymite crystals has taken on a pale yellowish-brown color and contains some minute dust-like inclusions. The glass has apparently taken some iron oxides into solution which accounts for the reddish-brown color of this portion of the brick.

Section of Zone 9: In section 9, the outlines of the coarser ganister particles are readily distinguishable from the finer-grained matrix. Some residual quartz is still present in most of the coarser of these particles, but the main portion consists of cristobalite. No tridymite was definitely identified in these particles. Residual quartz makes up about 7% of the total volume of the brick.

The matrix also consists predominantly of cristobalite, but a small amount of tridymite has also made its appearance. No residual quartz occurs in it. The lime silicate appears to be present in the matrix in the form of a glass. No crystalline silicate was observed.

The portion of the sample represented by section 9 has not been changed to any appreciable extent from the condition that it was in when originally placed into service.

(*b*) Insulated Brick

Section of Zone 1: This section is similar to section 1 from the uninsulated brick in all respects. The cristobalite grains are somewhat larger than in the uninsulated sample, but the individual cristobalite units which made up these grains are of the same size. Rather abundant black opaque iron-oxide dendrites associated with some yellowish-green to yellowish-brown crystalline silicate dendrites fill interstices between the cristobalite grains.

Almost all of the free silica in this section consists of cristobalite.

Section of Zone 2: This section corresponds closely in almost all respects to section 2 of the first sample. While the outlines of the original ganister particles are still recognizable, their boundaries are no longer sharp. They consist of considerably finer tridymite crystals than the matrix with sometimes a little cristobalite at the center.

The matrix consists of interlocking tridymite crystals up to 0.37 by 0.08 millimeter in cross-section. Abundant black opaque iron-oxide dendrites are comparatively uniformly distributed between the tridymite crystals. Instead of glass, a small amount of yellowish- to greenish-brown crystalline silicate, similar to that described from section 1 of the uninsulated sample, is associated with the iron-oxide dendrites.

Almost all of the free silica in section 2, consists of tridymite.

Section of Zone 3: This section is similar in all respects to section 3 cut from the first sample. The boundaries of the still recognizable ganister particles have become ragged and rounded by conversion into tridymite. They consist predominantly of cristobalite. Only a very small amount of residual quartz remains, less than in the corresponding section from the uninsulated sample.

The matrix consists of well-developed tridymite crystals ranging in cross-section from 0.07 by 0.025 millimeter to 0.1 by 0.03 millimeter. An appreciable quantity of yellowish-green glass fills interstices between the tridymite crystals.

The microscopic examination of the two samples indicates that the marked changes which have affected the brick (which was not insulated) less than one-half the distance back from the heated end have proceeded throughout the whole length of the insulated brick. The affected portions of both brick are made up of a cristobalite band adjacent to the exposed end and a tridymite band away from the source of the heat.

IV. Discussion

The visual inspection, chemical analysis, and petrographic examination indicate that zone 1 is essentially the same in the insulated and uninsulated brick, except that it is deeper in the insulated than in the uninsulated brick. The same is true of zones 2 and 2 and zones 3 and 3.

Probably the most important observation, from the standpoint of furnace operation, is that the multicolored section, zones 4 to 7 inclusive, which appears in the uninsulated brick is entirely missing from the insulated brick. It is as if this section had been pushed up past the end of the brick by the higher temperature of the insulated brick. This section is commonly known as a zone of weakness in the brick. When breakage occurs, resulting in large pieces (even up to half brick) dropping into the furnace, it frequently occurs through this zone of weakness. It appears probable that the absence of this zone of weakness in the insulated brick tends to minimize the danger of premature failure of the roof. The cause of the weakness of the multicolored section is not fully understood. There is nothing evident in the chemical analysis to account for the weakness, nor does the petrographic analysis seem to give an adequate explanation. Logically there must be an abrupt change in the coefficient of expansion from zones 3 to 4 or within the multicolored section, although, so far as is known, this has never been determined. R. B. Sosman in a personal communication suggests that the weakness may possibly be connected with the 1150° inversion in wollastonite, $CaO{\cdot}SiO_2$ (see Table I), but that evidence as to this is lacking. A determination of coefficient of expansion would be interesting.

The chemical analyses show iron oxide, lime, and alumina higher in some of the zones than in the original brick, which is in accord with previously published data. This is due to material absorbed from the furnace vapors and dust, which migrates from the hot toward the cooler end of the brick.

Other investigators have also found that the zone at the hot end of the brick consists predominantly of cristobalite. This is of course contradictory to the observations by LeChatelier[13] and indicates that the brick which he examined had not reached as high an average temperature as he supposed. In all probability, the inner zone of the brick examined by LeChatelier corresponded

[13] See footnotes 2 and 12.

TABLE II*

UNINSULATED BRICK FROM A BASIC OPEN-HEARTH FURNACE

Zone No.	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9
SiO_2	89.16	89.40	87.76	95.34	95.96	96.20	96.18	96.08	96.00
Al_2O_3	0.86	1.64	2.06	1.05	0.94	1.09	1.14	1.16	1.14
Fe_2O_3	6.86	6.30	4.20	1.03	0.86	0.63	0.68	0.68	0.68
MnO_2	0.70	0.56	0.26	None	None	None	None	None	None
CaO	1.96	1.88	5.42	2.46	2.10	1.86	1.88	2.04	2.08
MgO	0.07	0.08	0.07	0.10	0.08	0.06	0.06	0.06	0.07
Alkalis	0.70	0.68	0.39	0.19	0.19	0.20	0.18	0.17	0.21
Total	100.31	100.54	100.16	100.17	100.13	100.04	100.12	100.19	100.18

INSULATED BRICK FROM A BASIC OPEN-HEARTH FURNACE

Zone No.	No. 1	No. 2	No. 3
SiO_2	89.62	87.54	88.24
Al_2O_3	0.66	0.86	1.29
Fe_2O_3	6.58	8.12	4.27
MnO_2	0.86	0.76	0.28
CaO	2.34	3.02	5.88
MgO	0.08	0.19	0.07
Alkalis	0.47	0.37	0.11
Total	100.61	100.86	100.14

No. 1 Dense, light slate green
No. 2 Dense dark gray; few white grains
No. 3 Transition zone; many white grains
No. 4 Cream
No. 5 Purple tint (light)
No. 6 Yellow-cream
No. 7 Purple tint (dark)
} Banded zone
No. 8 Slightly altered (reddish brown)
No. 9 Unaltered (approximate analysis of both original samples)

* Analyses by B. C. Ruprecht, Harbison-Walker Research Department.

closely with zone 2 of the uninsulated brick in the present study.

The petrographic analysis shows that zone 8 contains a greater amount of tridymite than zone 9 although the temperature at the point at which the sample was taken had been at an average maximum temperature of about 800°C (1472°F), that is, 70°C below the lowest temperature at which tridymite is stable. On page 72, Dr. Sosman[12] discusses the recrystallization of cristobalite to form tridymite, in the presence of a flux at temperatures below 870°C.

Zone 1, the hottest portion of the brick, consists predominantly of cristobalite and zone 2 of tridymite. This suggests that the average effective temperature for the dividing plane was 1470°C, which is the upper temperature limit at which tridymite is stable.

The temperature taken from Fig. 3 for the dividing plane between zones 1 and 2 is 1535°C. From this, it appears possible that the temperature assumed for the inner face of the roof, *i.e.*, 1625C°, is too high. If a temperature of 1470°C is assumed for the dividing plane and the same temperature gradient as for the previously calculated curve, the average maximum temperature of the hot face of the furnace roof would be about 1545°C (2813°F). (See dotted curve Fig. 3.) The calculation is, of course, rather uncertain, as the actual conductivity of zone 1 is unknown.

In conclusion it may be said that the increasing use of insulation necessitates more accurate control of furnace operation and increased understanding of the refractories used. It is hoped that this study will contribute its small part to the total needed knowledge.

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REACTION-EXPANSION MEASUREMENTS ON CHROMITE AND ALLIED SPINELS*

By J. H. Chesters and C. W. Parmelee

Abstract

The rate of formation of spinel in mixtures of magnesia with alumina or chromic oxide (Cr_2O_3) was greatly increased by the addition of 2% of boric acid. When the three oxides were heated together in the molecular ratio ($2MgO + Al_2O_3 + Cr_2O_3$), reaction-expansion set in at a temperature much below that observed with the binary mixtures. The product appeared to be a mixture of green magnesium chromite with a pink colored spinel whose lattice edge was greater than that of magnesium aluminate but smaller than that of the chromite.

Test pieces made from unfired Cuban chromite began to shrink at 1300°C, and gave a final shrinkage of 2.2% after two hours at 1500°C. Microscopic examination showed that the serpentine had changed to a glass. The compensation of firing shrinkage by the addition of 20% of coarse Austrian magnesite or 10% of fine electrically fused magnesia was found to be due to the formation of a doubly refracting mineral resembling forsterite. With a 20% alumina addition, a firing expansion of 0.8% was obtained.

I. Introduction

In a previous paper,[1] an account was given of the measurement of reaction rates at high temperatures in mixtures of magnesia and alumina. It was shown that the progress of a reaction proceeding with an expansion could be followed with considerable accuracy by means of a "reaction-expansion" apparatus, the formation of about 0.1% of spinel resulting in a movement of one scale division. No simple relation between expansion and reaction could be developed, but the type of curve gave clear indications as to variations in the rate of reaction and recrystallization. A simple calculation, based on the knowledge of the density of the constituent oxides and of the product, indicates whether a reaction proceeds with an expansion or a contraction. In either case, it should be possible to study reaction rates from the observed expansion or shrinkage curves, although where shrinkage predominates it becomes

* Received August 24, 1934.

[1] J. H. Chesters and C. W. Parmelee, "Measurement of Reaction Rates at High Temperatures," *Jour. Amer. Ceram. Soc.*, 17 [3], 50 (1934).

more difficult to differentiate between shrinkage caused by reaction and that due to the presence of a liquid phase.

In practice, the expansion obtained is often much greater than would be expected from theoretical considerations, because when an expansion reaction proceeds rapidly the porosity of the test piece tends to increase. In previous researches on the expansion accompanying the hydration of dead-burned magnesite,[2] the observed expansions were also much greater than would be expected from simple density calculations.

The results given in this paper suggest the possibility of applying the reaction-expansion method to the study of changes in more complex systems, *e.g.*, chromite plus serpentine plus magnesia, and hence of determining the nature and extent of a number of reactions which have previously been little understood. At present the method is mainly qualitative, but we hope eventually to control grain size, etc., in such a way as to be able to make quantitative measurements of reaction rates, even in relatively complex systems.

II. Literature

Since a fairly complete account of the present state of our knowledge of chromite has been given by McDowell and Robertson,[3] Parmelee and Ally,[4] and Seil,[5] the literature will not be discussed at any length. It is now generally accepted that chromite ores of the type used for the manufacture of refractory materials consist of a complex spinel, together with subsidiary minerals, *e.g.*, serpentine. In calculating the mineralogical composition from the chemical analysis, the iron is assumed to be present in the complex spinel as FeO, and any magnesia not required to complete the spinel formula is assumed to be present in the bond. It is often suggested that chromite is essentially $FeO{\cdot}Cr_2O_3$, but no large deposits of this mineral are available, and many chromites, *e.g.*, the Cuban chromite, contain more $MgO{\cdot}Al_2O_3$ than $FeO{\cdot}Cr_2O_3$. The low magnesia-silica ratio of the gangue material together with the presence of impurities, such as lime, tends to yield a low-melting glass, which is responsible for the firing shrinkage and the low refractoriness under load usually associated with chromite brick.[6] In recent years, considerable improvements in the properties of chromite brick have been obtained by physical and chemical correction of the ores,[6] the addition of various amounts of magnesia having been the subject of a number of patents. A good deal has also been written on the concentration of chromite ores. Cirkel[7] and Doerner[8] describe the use of concentrating tables for the removal of gangue material. Other workers, such as Gill,[9] discuss the possibility of concentration by washing, but very little information is available on the concentration of ores for refractory purposes. Even if the gangue material could be completely removed, it is doubtful whether a better brick would result, since chromite, like most cubic minerals, shows little, if any, tendency to intercrystallize. The recent development of "Siemensit" refractories, made by electrocasting mixtures of various materials containing chromic oxide (Cr_2O_3), is another line of attack on the problem of producing refractory materials having the chemical properties of chromite without the physical disadvantages of the usual chrome brick.

A paper by Tyler and Rees[10] on the talc-magnesite minerals of the Anglo-Egyptian Sudan, although not bearing directly on chromite, is of considerable interest in connection with this paper since it shows the possibility of improving a talc-magnesite brick by raising the amount of magnesia sufficiently to form forsterite instead of enstatite. The work done by Heindl[11] on thermal expansion at high temperatures is also of interest since expansion curves on chromite ores show that shrinkage begins at 1500° even with a material prefired at 1800°, while with magnesite,

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[2] J. H. Chesters and W. Weyl, "The Drying of Magnesite Bricks—Volume Changes Accompanying Hydration," *Trans. Ceram. Soc.* [Eng.], **32**, 201 (1933).

[3] J. S. McDowell and H. S. Robertson, "Chrome Ore Refractories," *Jour. Amer. Ceram. Soc.*, **5** [12], 865 (1922).

[4] C. W. Parmelee and A. Ally, "Some Properties of Chrome Spinel," *ibid.*, **15** [4], 213 (1932).

[5] G. E. Seil, "Petrography and Heat Treatment of Chromite Refractories." Paper presented at the Cincinnati Meeting of the American Ceramic Society, 1934.

[6] J. H. Chesters and W. J. Rees, "High Temperature Tensile Tests," *Proc. Ann. Conf. Nat. Assn. Clayworks Managers*, **2** (1931); *Refrac. Jour.*, **7** [11], 475–79 (1931).

[7] F. Cirkel, "Report on Chromite Deposits in the Eastern Townships—Province of Quebec," Ottawa Govt. Printing Bur., 1909.

[8] H. A. Doerner, "Concentration of Chromite," *U. S. Bur. Mines Rept. of Invest.*, No. 3049 (Nov., 1930).

[9] A. C. Gill, *U. S. Geol. Surv.*, No. 712 (1919); No. 742 (1922).

[10] W. H. Tyler and W. J. Rees, "An Investigation into the Utility of a Deposit of Magnesite-Bearing Rocks in the Anglo-Egyptian Sudan," *Trans. Ceram. Soc.* [Eng.], **33** [3], 104 (1934); *Ceram. Abs.*, **13** [8], 220 (1934).

[11] R. A. Heindl, "Thermal Expansion of Refractories to 1800°C," *Bur. Stand. Jour. Research*, **10**, 715 (June, 1933).

where solution of magnesia in the bond is possible, prefiring at 1800° greatly increases the temperature at which subsequent shrinkage sets in.

III. Experimental Procedure

(1) Raw Materials The chemical analyses of the chromite and magnesia used in the following tests are given in Table I.

TABLE I

CHEMICAL ANALYSES OF RAW MATERIALS

	Unfired Cuban chromite brick	Electrically fused magnesia	Austrian magnesite brick
Cr_2O_3	31.42		
Al_2O_3	28.54	0.33	2.17
MgO	18.22	95.85	84.74
Fe_2O_3	15.56*	0.61	4.10
SiO_2	5.19	1.21	4.40
CaO	0.04	2.49	4.49
Loss on ignition	1.61	0.30	0.30

* Iron determined as Fe_2O_3.

The samples of electrically fused magnesia and Austrian magnesite B were taken from the batches used in previous researches on spinel formation[1] and the firing of magnesite brick.[12]

The unfired Cuban chromite brick (supplied by a well-known refractories manufacturer) was found to have a grading as shown in Table II, column (i). The grading of the Austrian magnesite B is given in column (ii). The chromite brick was said to be 100% Cuban ore, the observed plasticity of the moistened batch being due to the large proportion of "through 150-mesh" material. In one test a sample of electrically fused alumina was used. This was also taken from the batch used in the earlier work[1] which was supplied as 99.5% Al_2O_3. The chromic oxide was obtained by pressing the ordinary color oxide used for glaze preparations into tablets and firing it at 1450° for several hours.

TABLE II

GRADING OF RAW MATERIALS

Tyler sieves	(i) Unfired Cuban chromite brick	(ii) Austrian magnesite B
On 8-mesh	3	
8–28	21	37
28–65	20	13
65–150	14	16
Through 150	42	34

[12] J. H. Chesters and C. W. Parmelee, "Burning of Magnesite Brick. I," *Trans. Ceram. Soc.* [Eng.], **32**, 349 (1933).

(2) Preparation of the Test Piece and Preliminary Measurements No detailed account will be given of the methods used in the determination of powder density, bulk volume, and linear dimensions since they have all been fully described in a previous publication.[1] All of the test pieces used were small cylinders about 1.5 inches in height and 0.88 inch in diameter and were prepared by pressing the moistened material (5% water addition) under 10,000 pounds per square inch for thirty seconds. After drying and measuring they were placed in the reaction-expansion apparatus and heated to the maximum temperature in about fifty-five minutes, readings of the temperature and test-piece length being taken every five minutes. The test piece was maintained at the maximum temperature for two hours and then cooled and remeasured. The various curves given in Figs. 1 to 7 show the initial thermal expansion followed by firing expansion or shrinkage. The expansion is given in scale divisions (1 div. = $^1/_{10,000}$ inch) and not per cent, since the test pieces varied slightly in length, but for all practical purposes, it may be assumed that an expansion of 160 divisions is equivalent to an expansion of 1%. The expansion apparatus and the molybdenum wire-wound furnace are the same as were used in the earlier work. The furnace has now made seventy-four tests without any sign of deterioration.

IV. Results

(1) Magnesia-Alumina Mixtures Figure 1 shows the expansion curves obtained when magnesia and alumina, mixed in the proportions required to form spinel, are heated either with or without 2% of boric acid (B_2O_3). Fine electrically fused oxides were used, half being of 0.06 millimeter and half of 0.09 millimeter diameter. In the presence of boric acid, Fig. 1, curve (2), reaction becomes very rapid at about 1300°, and is complete in about ten minutes. The sudden expansion then changes to an almost equally rapid shrinkage, due to recrystallization. Figure 1, curve (1), shows that without boric acid the reaction proceeds much more slowly. X-ray (Debye-Scherrer) patterns reveal a considerable amount of residual alumina in the test piece fired without boric acid. Table III shows that, even at the end of the test, the porosity of the boric-acid test piece had increased by about

10%. It is this increase that explains the large expansions (5.7% vertically and 11.8% horizontally) obtained, as compared with those expected from density calculations. A study of

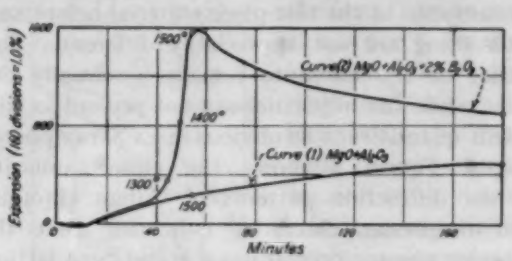

FIG. 1.—Rate of spinel formation.

either the initial expansion rates or of the time required to give complete reaction suggests that the presence of the boric acid increases the reaction rate between ten and twenty times. The

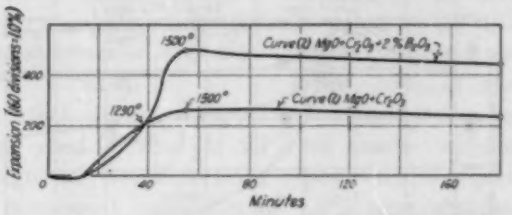

FIG. 2.—Influence of boric acid on reaction rate at 1500°C.

exact mechanism of this acceleration is not clear but it is presumably due either to the solution of magnesia and alumina in the boric oxide with subsequent precipitation of spinel, or to the formation of borates followed by spinel-forming reactions of the magnesium borate + alumina = spinel + boric oxide type.

(2) Magnesia-Chrome Oxide Mixtures

The magnesia used was again a 50:50 mixture of the 0.09- and 0.06-millimeter grain size material, while the chromic oxide was the raw material already described but ground to pass a 150-mesh screen. Figure 2 shows the curves obtained when molecular mixtures, either with or without boric acid, are heated to

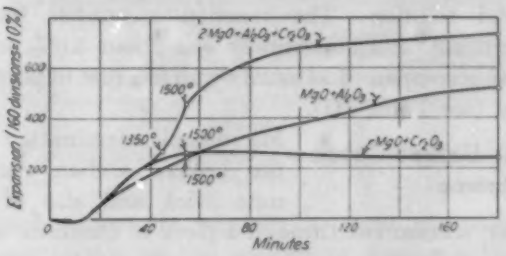

FIG. 3.—Reaction-expansion curves for spinels. Expansion (160 div. = 1.0%).

1500°C. In comparison with the magnesia-alumina mixtures the reaction-expansions are small, but the difference in reaction rate with and without boric acid is again demonstrated. With the boric acid present, reaction is quite marked at temperatures as low as 1230°. X-ray examination showed that the product in both cases was essentially 100% spinel.

TABLE III
SUMMARY OF TEST RESULTS

Test piece	Material	Firing temperature	Density* (1)	Density* (2)	Bulk-Density (1)	Bulk-Density (2)	Porosity (1)	Porosity (2)	Expansion (%) (vertical)	Expansion (%) (horizontal)
34	$MgO + Al_2O_3$	1500°C	3.83	3.67	2.22	1.89	42.0	48.5	3.0	6.3
47	$MgO + Al_2O_3 + 2\%B_2O_3$	1500	3.83	3.50	2.15	1.62	44.0	53.5	5.7	11.8
33	$MgO + Cr_2O_3$	1500	4.70	4.30	2.79	2.71	40.5	37.0	0.8	1.0
36	$MgO + Cr_2O_3 + 2\%B_2O_3$	1500	4.70	4.33	2.68	2.45	43.0	43.5	2.1	2.4
35	$2MgO + Al_2O_3 + Cr_2O_3$	1500	4.29	3.95	2.75	2.45	36.0	38.0	4.0	3.9
37	Cuban chromite	1500	3.83	3.86	3.15	3.26	18.0	15.5	−2.2	−1.0
38	Cuban chromite	1400	3.83	3.87	3.13	3.20	18.5	17.5	−1.4	−0.8
	Austrian magnesite B : Cuban chrome									
42	10% : 90%	1500	3.80	3.85	3.03	3.07	20.0	20.0	−1.0	−0.3
41	20 : 80	1500	3.77	3.84	3.15	2.96	16.5	23.0	0.1	0.5
43	50 : 50	1500	3.68	3.71	2.76	2.75	25.0	26.0	−1.2	0.0
44	100 : 0	1500	3.54	3.54	2.44	2.78	31.0	21.5	−6.4	−2.9
45	10% E. F. magnesia† 90% Cuban chromite	1500	3.80	3.89	3.06	2.95	19.5	24.0	0.3	1.0
46	20% E. F. alumina‡ 80% Cuban chrome	1500	3.85	3.87	2.92	2.78	24.5	28.0	0.8	1.6

* 1 and 2 indicate the values before and after firing.
† Electrically fused magnesia.
‡ Electrically fused alumina.

(3) Magnesia-Alumina-Chrome Oxide Mixtures (Ratio 2MgO:-Al_2O_3:Cr_2O_3)

Figure 3 shows that the reaction in the ternary mixture becomes rapid at 1350°, much below the rapid reaction temperature in the binary mixtures. X-ray and microscopic examination show that the product is a mixture of the green magnesium chromite with a pink colored spinel having a lattice edge that is smaller than that of magnesium chromite but much greater than that of the aluminate. This material is presumably a mixed spinel or possibly the aluminate with a great deal of impurity in solid solution. The reaction expansion both vertically and horizontally was about 4.0% and was accompanied as usual by an increase in porosity (see Table III).

(4) Unfired Cuban Chrome

Microscopic examination of the unfired Cuban chromite brick and also of a thin section cut through a piece of chromite ore

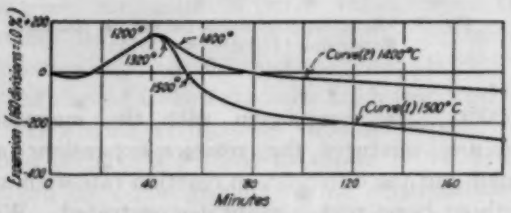

FIG. 4.—Firing shrinkage curves of Cuban chromite.

similar to that used in the preparation of the brick batch showed the presence of a good deal of doubly refracting material whose refractive index and birefringence agreed with those of serpentine. The slice suggested that the serpentine had undergone weathering. Examination of the various sieve sections of the unfired brick material shows that the serpentine tends to break away from the chromite during grinding.

When test pieces made from the unfired brick were heated, thermal expansion first occurred, but at 1300° rapid shrinkage began, which reached 2.2% when the test piece was held for two hours at 1500° (Fig. 4, curve (1)). At 1400°C (curve (2)), the initial shrinkage rate was considerably less, but a final shrinkage of 1.4% occurred after two hours. The powder density of the chromite increased, as previously observed by Parmelee and Ally,[4] but the porosity decreased. The explanation of the shrinkage (and also of the low refractoriness under load) of the ordinary chrome brick is that the serpentine and other impurities melt to form a glass, which draws together the chromite grains. Microscopic examination shows that the serpentine has disappeared and given place to a brownish isotropic material. X-ray photographs of the test-piece material before and after firing are not appreciably different. The lattice of the chromite remains essentially the same while the impurities are not present in sufficient quantities to be obvious in an X-ray photograph. Figure 8 shows the close similarity of the diffraction patterns of Cuban chromite and magnesium-chromite, indicating that the complex chrome crystal has a spinel-type lattice.

(5) Cuban Chromite-Austrian Magnesite Mixtures

The addition of Austrian magnesite to a chromite brick batch has long been used as a method of reducing the firing shrinkage. Since no explanation of this phenomenon could be found in the literature, a series of tests ranging between (0–100) and (100–0) magnesite-chromite mixtures was made. Figure 5 shows the curves obtained on firing. The Austrian magnesite B (100–0) showed a firing shrinkage of 6.4% and that of the Cuban chromite, 2.2%. The (20–80) mixture, which has been considered as particularly suitable for shrinkage compensation, actually showed a small expansion on firing, the small shrinkage observed in Fig. 5 being due to a slight collapse in the system. This is observed even when a fired Alundum test piece is used. Microscopic and X-ray examination of the product (Fig. 9) showed that only about one-half of the magnesia had been used. No appreciable change was observed in the lattice distance, which suggests that the shrinkage compensation could not have been caused by solid solution in the spinel.

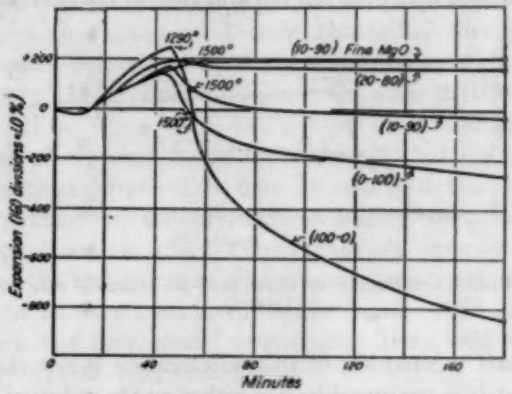

FIG. 5.—Reaction-expansion curves of magnesite-chromite mixtures.

Under a microscope, it appears that the reaction has been between the magnesia and the melt formed from the impurities. It would therefore seem probable that the shrinkage compensation is due to reaction between the liquid melt and the solid magnesia, the magnesia being changed *in situ* to a doubly refracting material resembling forsterite. This change takes place with a marked expansion, which forces apart the chromite grains and thus compensates for the shrinkage produced elsewhere by the melting of the serpentine. When 10% of electrically fused magnesia of 0.06-millimeter diameter was used instead of 20% of coarse Austrian magnesite, a vertical firing expansion of 0.3% and a horizontal expansion of 1.0% were obtained. This rules out the suggestion that shrinkage compensation is due solely to increased viscosity of the melt, since this could not account for an expansion. The increase in the porosity of the compensated materials on firing (see Table III) is also in agreement with this explanation. Additional tests were made with the (10–90) and (50–50) Austrian magnesite-chromite mixtures, compensation of shrinkage being much less than with the (20–80) mixture. The final values of the horizontal and vertical firing shrinkages as a function of the ratio of the mixture are shown in Fig. 6. For coarse magnesite additions, it is evident that the (20–80) mixture is about the best, but where the magnesia is added as fine-grain material of about 0.06-millimeter diameter even 10% is enough to give not only shrinkage compensation but actually a slight expansion. A calculation of the amount of magnesia that must be added to a Cuban chromite brick, having the chemical analysis* given in Table I, in order to raise the magnesia-silica ratio to that of forsterite shows that only a small part of the magnesia in the (20–80) batch is really necessary for this purpose.

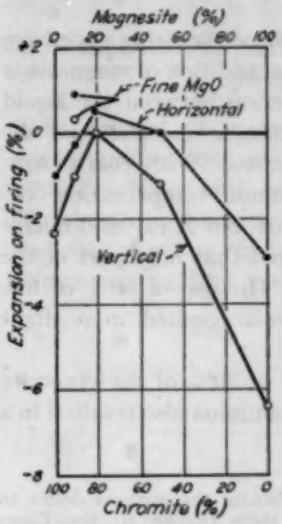

FIG. 6.—Firing expansion and shrinkage of magnesite-chromite mixtures.

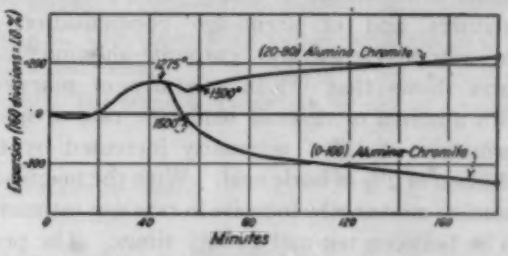

FIG. 7.—Shrinkage compensation in alumina-chromite mixtures.

(6) Cuban Chromite—Alumina Mixtures

The replacement of 20% of the chromite by fused alumina of 0.06-millimeter diameter resulted in a firing expansion of 0.8% vertically and of 1.6% horizontally (see Fig. 7). Both microscopic and X-ray examina-

* Assuming all the iron to be present in the spinel as FeO.

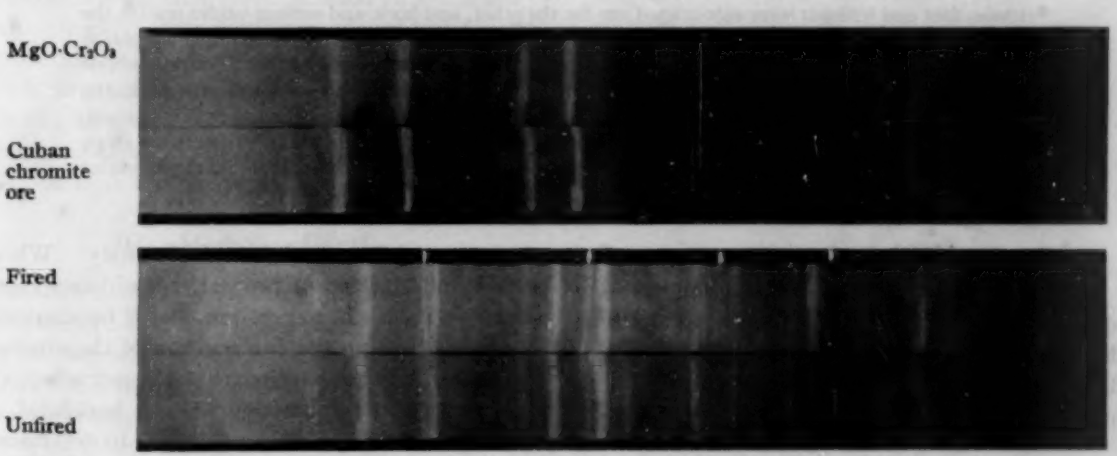

FIG. 8.—(Upper) the spinel-type lattice of Cuban chromite. FIG. 9.—(Lower) (20–80) Austrian magnesite-Cuban chromite mixture.

tions suggest that only a part of the alumina was used. The nature of the reaction which causes expansion is, as yet, rather obscure, since the only double-refracting material visible in the fired sample appears to be residual alumina.

V. Conclusions

The application of reaction-expansion measurements to the study of binary- and ternary-oxide mixtures and of shrinkage compensation in chromite-magnesia and chromite-alumina mixtures shows that (1) in mixtures of magnesia with alumina or chromic oxide the rate of spinel formation at 1500° is greatly increased by the addition of 2% of boric acid. With the magnesia-alumina mixture the increase in rate was estimated to be between ten and twenty times. The presence of the boric acid results in a lowering of the temperature at which reaction expansion becomes obvious by about 200°.

(2) When magnesia, alumina, and chromic oxide are heated together in the ratio ($2MgO \cdot Al_2O_3 \cdot Cr_2O_3$) the reaction expansion begins at a lower temperature and proceeds more rapidly than in binary mixtures. The product appears to be a mixture of the green magnesium chromite with a second pink colored spinel whose lattice is intermediate between that of the aluminate and that of the chromite.

(3) The compensation of the firing shrinkage of a chromite brick by the addition of magnesia is shown to be due to reaction between the liquid bond formed from the gangue material and the magnesia, yielding forsterite. With coarse Austrian magnesite, maximum compensation occurred for a 20–80 mixture, but X-ray and microscopic examination showed that only part of the magnesia had reacted. The use of 10% of fine electrically fused magnesia resulted in a slight expansion.

(4) The replacement of 20% of the chromite by fine electrically fused alumina also resulted in a firing expansion.

Acknowledgments In conclusion, the authors desire to express their thanks to the Commonwealth Fund of New York and to the University of Illinois for enabling them to carry out this work; also to C. L. Thompson for help with the microscopic investigations.

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STRENGTH AND YOUNG'S MODULUS OF SOME GROUND-COAT ENAMELS FOR SHEET IRON*

By W. N. Harrison, S. M. Shelton, and W. H. Wadleigh

Abstract

Eleven enamel compositions of the sheet-iron ground-coat type were studied. For nine compositions, flint and feldspar were substituted one for the other, and boric and sodium oxides one for the other. For the remaining two, a given combination of flint and feldspar and a given combination of boric and sodium oxides were substituted one for the other. Tests were made for Young's modulus of elasticity, tensile strength, and modulus of rupture. The shape of the stress-strain curve, the effect of the duration of the stress period on apparent strength, and the strength distribution in specimens of the respective enamels were investigated. The changes in modulus of rupture were not large, but this property varied systematically with the composition, as did the scatter in the modulus of rupture and also the extensibility.

I. Introduction

The desirability of accumulating information concerning the strength and Young's modulus of elasticity of enamels has often been emphasized. It has been suggested that the compositions of enamels should be adjusted to secure high strength and low modulus of elasticity. While such a combination of properties is obviously desirable in itself, the suggestion that it be attained through adjusting the composition of the enamel rests upon the assumption that the net effect of the changes in composition will be beneficial.

The present study was undertaken to determine the effects of some common variations in composition of sheet-iron ground-coat enamels upon the

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strength and upon Young's modulus of elasticity, and to estimate the degree of importance which should be placed upon these changes in properties.

II. Composition of Enamels and Preparation of Specimens

The method of preparation of the enamels, their computed compositions, and the results of chemical analyses have been previously reported.[1] The scheme of variations in composition is indicated in Table I of this paper.

Numerous rods of each enamel were drawn. The diameters in one group averaged about 0.75 millimeter and ranged between 0.6 and 0.9 millimeter. In the other group, the diameters averaged about 0.25 millimeter and ranged between 0.2 and 0.3 millimeter.

For annealing they were inclosed in a shallow box made of $^1/_4$-inch aluminum, placed in a small electric muffle furnace, and heated for approximately one-half hour at 5 to 10°C above their softening temperatures as indicated by the interferometer,[2] then cooled in the furnace well below their "critical temperatures" before removing.

TABLE I

COMPOSITION OF ENAMELS AND RESULTS OF TESTS

Enamel designation	Variable constituents†				Young's modulus of elasticity (kg./mm.²)	Modulus of rupture (constant load) (kg./mm.²)	Scatter (root mean square deviation from median strength) (kg./mm.²)	Extensibility $\left(\frac{\text{modulus of rupture}}{\text{Young's modulus}}\right)$ (%)
	Feldspar (%)	Flint (%)	Sodium oxide (%)	Boric oxide (%)				
A	35	25	17	13	8250	14.2	3.22	0.172
B	35	25	14	16	8220	15.0	3.05	.182
C	35	25	11	19	8190	15.8	2.80	.193
D	30	30	17	13	8180	14.7	3.21	.180
E	30	30	14	16	8230	15.4	3.01	.187
F	30	30	11	19	8200	16.1	2.86	.196
G	25	35	17	13	8360	13.5	2.96	.162
H	25	35	14	16	8320	14.3	2.67	.172
I	25	35	11	19	8290	14.7	2.58	.177
J	27	27	17	19	8390	11.9	1.93	.142
K	33	33	11	13	8330	15.7	2.78	.189

† Each enamel contained, in addition to the above tabulated constituents, 7.7% fluorspar, 1.7% manganese oxide, and 0.6% cobalt oxide.

III. Methods of Test

The size and shape of the specimens were observed before test by sliding them from end to end, in different positions of rotation, through the jaws of a dial micrometer. Specimens which were materially bent or tapered were rejected.

(A) Young's Modulus of Elasticity

Transverse tests of the 0.75-millimeter specimens were made. The span was 9 centimeters. Three different loads were applied at midspan by placing weights on a small aluminum pan suspended by a fine wire from the specimen. The deflections were observed with a micrometer microscope. About ten specimens of each enamel were tested. Some of the specimens were slightly elliptical, and these were tested with the major radius horizontal.

NOTE: The modulus of elasticity for rods of approximately circular cross-section was computed from the formula

$$E = \frac{FL^3}{12\pi Dr^4}$$

and for the slightly elliptical rods, lying with the major axis horizontal, from the formula

$$E = \frac{FL^3}{12\pi Dab^3}$$

Where E = modulus of elasticity
F = load
L = length of span
D = deflection
r = radius of circular rod
a and b = major and minor radii, respectively, of an elliptical rod.

(B) Tensile Strength

The method of determining the tensile strength was similar to that described by Hall[3] except that the loads were applied directly to the lower end of the vertical specimen, and the ends of the speci-

[1] W. N. Harrison and B. J. Sweo, *Bur. Stand. Jour. Research*, **10**, 189 (1933); R. P. 524.

[2] See Table I of article referred to in footnote 1.

[3] F. P. Hall, "Influence of Chemical Composition on Physical Properties of Glazes," *Jour. Amer. Ceram. Soc.*, **13** [3], 182 (1930).

men, after being passed through close-fitting holes in the sockets, were fused to form small balls, which were embedded in sealing wax within the sockets. The 0.25-millimeter specimens were used, and care was taken to align the specimens and sockets. An average of about 80 specimens of each enamel were tested for tensile strength.

(C) Modulus of Rupture

(1) Increasing Load In this test the 0.75-millimeter specimens were supported in a horizontal position by supports 2 centimeters apart, resting on a bar which replaced one pan of a balance. A stationary rod was located immediately above and at right angles to the specimen, midway between the supports. Load was applied by allowing mercury to flow from a burette into a vessel on the other pan of the balance.

NOTE: The modulus of rupture was computed from the formula

$$M = \frac{8FL}{\pi d^3}$$

Where M = modulus of rupture
F = load
L = length of span
d = diameter

Specimens of approximately circular cross section only were tested.

Loads were applied at half-minute intervals in such manner that the computed stress increments were 1 kg./mm.^{2} Twenty-seven specimens of each enamel were loaded to failure.

(2) Constant Load The 0.75-millimeter specimens with a 2-centimeter span were used, the load on each specimen being constant. The supports consisted of parallel bars so arranged that twenty specimens could be tested simultaneously. For each enamel composition ten specimens were loaded individually at a computed stress of 5 kg./mm.^{2}, ten at 6 kg./mm.^{2}, and so on up to 24 kg./mm.^{2}, a total of 200 specimens being used. The loads were applied gently and the specimens allowed to stand until failure or until a period of 23 hours had elapsed. Experience in several hundred cases showed that while a significant number of failures occurred between the seventh hour and the twenty-third hour after loading, a negligible number of failures occurred during an additional 24 hours and hence the tests were limited to 23 hours.

IV. Results and Discussion

The stress-strain relation appeared to be linear up to the point of failure[4] and independent of the loading rate. Observations were made under various loading rates, including one which caused failure in 10 minutes and one in 80 minutes. It was also noted that specimens which were allowed to stand under load nearly sufficient to cause failure in the allotted time remained as long as 96 hours with no significant change in deflection.

(A) Young's Modulus of Elasticity

The average value of Young's modulus for each enamel is given in Table I. The most noticeable feature about these values is that they all fall within a narrow range, between 8200 and 8400 kg./mm^2. If the first nine enamels, however, are divided into three groups, the flint and feldspar content remaining constant in each group, it is evident that the third, containing 25% feldspar and 35% flint, has a slightly higher modulus of elasticity than either of the other groups in which the percentages of these constituents are 30–30 and 35–25, respectively. This relation is apparent in Fig. 1, curve I.

To determine the significance of the changes in Young's modulus with composition shown by the three average values in Fig. 1, a statistical analysis of the data was made. The difference in magnitude between the two lower average moduli is not significant, but the difference between the lowest and highest is about $4^1/_2$ times the probable error of this difference, that is, the prob-

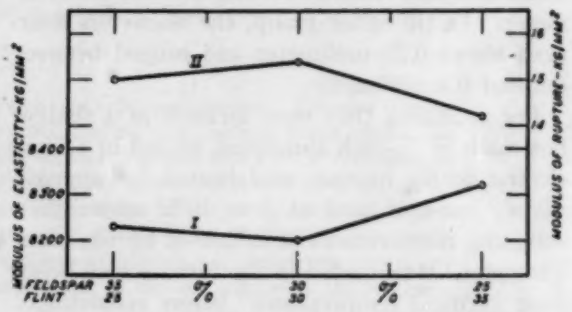

FIG. 1.—The effect of changes in feldspar and flint content upon modulus of elasticity (curve I) and modulus of rupture (curve II) of the enamels.

[4] This observation is in agreement with that of Griffith on glass. See *Trans. Roy. Soc.* (London) [*A*221], 177 (1920).

ability of its occurring as a result of chance errors of sampling is only about three in a thousand, and hence it is considered significant.[5]

The modulus for enamel J, with high flux content and low refractory content, and that for enamel K, with low flux and high refractory, are nearly equal.

(B) Strength

(1) Tensile Strength The grand average of the tensile strength values for all of the enamels is given in Table II. No correlation of changes in tensile strength with changes in composition was warranted on account of inadequate agreement between check determinations. Repeat tests on groups of about 50 specimens each, made at different times, gave average results which were significantly different

TABLE II

AVERAGE STRENGTHS OF THE ENAMELS

Tensile strength (kg./mm.²)	Modulus of rupture	
	Increasing load (kg./mm.²)	Constant load (kg./mm.²)
23	25	15

but not consistently higher or lower on the second trial, the difference amounting in some cases to as much as 20%. It was suspected that variation in room temperature constituted an important factor, probably because of its effect upon the sealing wax used in the sockets. A limited number of tests at known temperatures tended to confirm this explanation, but no positive statement is warranted.

(2) Modulus of Rupture under Increasing Load The grand average of the results on modulus of rupture under increasing load for all the enamels is given in Table II. No correlation of changes in this property with changes in composition was warranted because the scatter in results was too great, in relation to the small differences in strength, to permit the establishment of significant trends from 27 specimens of each enamel.

(3) Modulus of Rupture under Constant Load An important advantage of the method of test at constant load is that the scatter in results is less than that of the increasing load test. This effect was attained because many of the specimens which at first sustained stresses well beyond the average strength failed later during the test period, thus reducing the dispersion.

(a) Strength Distribution of Different Specimens of the Same Enamel The strength distribution of the specimens of each enamel was estimated in the following manner. The results of the constant load test at the end of the test period were put in graphical form by plotting cumulative per cent failure against computed stress. The former was calculated from the formula

$$P = \frac{100n}{N + n}$$

Where P = cumulative per cent failure
n = number of specimens which failed at and below a given stress
N = number which did not fail at and above the same stress.

Plotting P against stress gave a typical cumulative S curve from which it was easy to determine by interpolation the stress at which $P = 50$, that is, the median modulus of rupture which is reported in Table I. Since the values of P at different stresses are not independent, this operation amounted to smoothing the curve. Frequency distribution polygons were prepared from these cumulative curves for each enamel, and the deviations from the respective median strengths of the eleven enamels were plotted in a composite frequency distribution polygon. A normal distribution curve was fitted to this polygon, and the fit appeared from visual inspection to be good. The point to be emphasized here is that the apparent strength distribution is not conspicuously skewed.[6] Although the root mean square deviation of the strengths of individual specimens from the median strength of a given enamel varies with the composition, as shown in Table I and discussed further in the paper, it was approximately 3 kg./mm.² for most of the enamels.

(b) Effects of Variation in Composition on Modulus of Rupture The modulus of rupture under constant load is given in Table I and in Fig. 2. From these data it is apparent that substituting 3% boric oxide for 3% sodium oxide caused an increase in strength in all cases, averaging 0.7 kg./mm.². The increase in flint from 25 to 30%

[5] Yule, Introduction to Theory of Statistics. Charles Griffin & Co., London (1932); Fisher, Statistical Methods for Research Workers. Oliver and Boyd, London (1932).

[6] The skewness of the composite frequency distribution of deviations was computed to be only 0.1 (see footnote 5).

at the expense of feldspar caused a small increase in strength, averaging 0.4 kg./mm.^{2}, but the further increase of flint to 35% accompanied by a reduction in feldspar to 25% caused an average reduction of 1.2 kg./mm.^{2}.

The effect of the feldspar-flint content is shown also in curve II, Fig. 1. The rise of 0.4 kg./mm.^{2}, corresponding to a change in the flint and feldspar contents, is not considered significant since the magnitude of the determined difference is only about 50% greater than the probable error of this difference, but it seems worthy of mention since, as shown in Fig. 2, it occurred in all three cases. The other changes in strength with composition shown in Fig. 2 are considered to be significant.

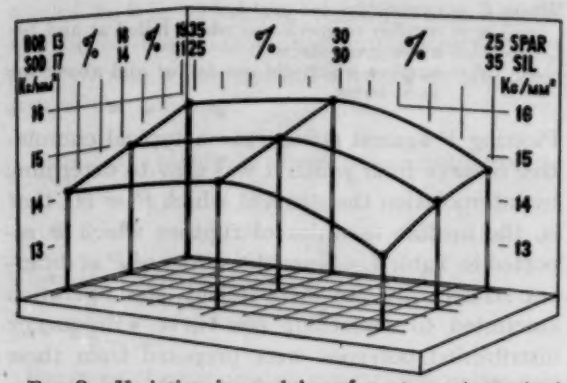

FIG. 2.—Variation in modulus of rupture at constant load with the composition of the enamels. SPAR = feldspar (considered as a unit); SIL = silica added as flint; BOR = boric oxide; SOD = sodium oxide.

Enamel J, with low refractory and high flux content, had the lowest strength of the group, while enamel K, with high refractory and low flux content, had a strength nearly as great as the strongest in the group. The maximum spread between the extreme moduli of rupture was only about 4 kg./mm.^{2}, however, and all but one of these enamels had moduli of rupture within a spread of about 2.5 kg./mm.^{2}.

(c) Effect of Variations in Composition on Scatter in Results

The scatter in the results of tests on modulus of rupture, with constant load, varied systematically with the composition and is given in Table I in terms of the root mean square deviation of the strengths of individual specimens from the median moduli of rupture. This property is important because the smaller the scatter the less liability of failure below the reported strength. The substitution of boric oxide for sodium oxide caused a decrease in the scatter in all cases, although it caused an increase in strength. With the substitution of silica for feldspar, however, the scatter tended to vary directly with the strength. In the case of enamels J and K also, the scatter varied directly with the strength, enamel J having the lowest value of the group for both properties.

(4) Influence of Size of Specimen and Duration of Loading Period upon Apparent Strength

The results of the tensile strength tests showed a distinct trend toward higher apparent strength with smaller diameter, which was in agreement with the findings of Griffith.[7] In the present work, however, the rate of loading in kilograms per minute was constant, so that the stress increased more rapidly in the smaller specimens. This fact leaves open the question of whether the higher apparent strength of the smaller specimens was not traceable, at least partially, to the higher rate of increase of stress. The drop in apparent strength (modulus of rupture) from 25 kg./mm.^{2} to 15 kg./mm.^{2} as shown in Table II for tests in which the only known difference was the time factor, suggests that this factor may have played an important part in producing the observed relation between apparent strength and diameter. The effect of time on specimens under constant load is illustrated by a tabulation of 110 specimens tested at the nearest computed stress to the median modulus of rupture. The results were as follows:

57 specimens did not fail.
4 failed immediately.
11 failed between 1/4 min. and 1 min. after loading.
11 failed between 1 min. and 10 min. after loading.
14 failed between 10 min. and 3 hr. after loading.
13 failed between 3 hr. and 23 hr. after loading.

(C) Extensibility

Since the stress-strain relation was linear to the failure point of the enamel specimens, it was considered justifiable to compute the extensibility as the ratio of the modulus of rupture to Young's modulus, and the resulting values are given in the last column of Table I. They fall within a range of 0.14 to 0.19% and are approximately proportional to the moduli of rupture, since Young's modulus was almost constant. The correlation with composition is therefore the same as in the case of the modulus of rupture with constant load.

[7] Griffith, *Trans. Roy. Soc.* (London) [*A*221], 181 (1920).

(D) Comparison of Results with Some Published Data

No detailed comparison of the present results on strength and elasticity with those which have been published on glazes and glasses[8] can be made, because the compositions are different and the factors given in the literature for calculating these properties do not include values for all of the constituents used in this study. The order of magnitude, however, is the same for the results reported here as for previously published results on Young's modulus and on the tensile strength of specimens of glazes and glasses having comparable diameters. Danielson and Sweely[9] reported compressive strengths of ground-coat enamels about $2^1/_2$ to 5 times greater than the mean tensile strength and the moduli of rupture reported here, which ratios are of reasonable order of magnitude. The moduli of elasticity reported in the present paper are within the range of the moduli of elasticity in compression reported by those authors.

(E) Degree of Importance of Variations in Young's Modulus, Strength, and Extensibility of the Enamels Studied

It is evident from Table I that the substitutions of flint for feldspar and of boric oxide for sodium oxide and *vice versa* caused such a small effect upon Young's modulus that no consideration need be given to variations in this property when a change of ground-coat composition within the investigated limits is contemplated.

The changes in modulus of rupture are more pronounced, but are not large, either in actual magnitude or in percentage. It seems doubtful that a change of composition for the sake of increasing the modulus of rupture would be justified when working within the investigated limits of composition unless other properties were also improved. For instance, in changing from composition A to composition C, the differential expansion between the enamel and the iron is markedly increased, as may be computed from published factors. The fact is well established that the expansivity of enamels is a major consideration in determining their fitness for use, and the advisability of making a change which will affect this property adversely to gain a small improvement in strength is open to question.

The extensibility of an enamel may be of more practical importance than Young's modulus and modulus of rupture. For instance, in fixing an enameled panel into place, warpage may be overcome by force, causing distortion of the enamel. If its extensibility is sufficient to permit the required elongation without failure, no immediate damage results and the absolute magnitudes of the strength and Young's modulus do not vitally affect the situation. Since, however, the percentage variation in the extensibility of the enamels studied is approximately the same as that in the modulus of rupture, the former property is thought to merit no more weight than the latter in considerations governing the selection of a composition within the investigated field to suit a given purpose.

It should not be concluded from these results that the strength, Young's modulus, and extensibility never vary to an important extent in enamels, since other types of enamels and more drastic variations in composition might produce different results.

V. Conclusions

(1) The investigated changes in composition of a single type of enamel affected Young's modulus of elasticity very slightly and affected the modulus of rupture and the extensibility to only a moderate extent, which might readily be outweighed in importance by more effective variations in other properties. Nevertheless, definite correlations of these properties with composition were possible.

(2) An increase of the boric oxide content from 13 to 19%, with a corresponding reduction in sodium oxide from 17 to 11% in a typical case, caused an increase in the modulus of rupture from 14.2 to 15.8 kg./mm.^{2} and an increase in the extensibility from 0.172 to 0.193%, but caused a decrease in the scatter of results on modulus of rupture.

(3) An increase of the flint content from 30 to 35%, with a corresponding reduction in feldspar from 30 to 25%, in a typical case caused a decrease in modulus of rupture from 15.4 to 14.3 kg./mm.^{2}, a decrease in the scatter of results on modulus of rupture, and a decrease in extensi-

[8] Hall (see footnote 3), in addition to reporting his own results, gives a bibliography on this subject.

[9] R. R. Danielson and B. T. Sweely, "The Relation between Composition and Properties of Enamels for Sheet Steel," *Jour. Amer. Ceram. Soc.*, **6** [10], 1011 (1923).

bility from 0.187 to 0.172%, but caused an increase in the modulus of elasticity from 8230 to 8320 kg./mm.².

(4) The frequency distribution of the strengths of different specimens of the respective enamels was approximately symmetrical.

(5) The rate of loading had no significant effect upon the modulus of elasticity, which remained constant up to the stress causing failure. It had a marked effect, however, upon the apparent modulus of rupture, failure occurring at substantially lower stresses with increased duration of the stress periods.

Acknowledgment The authors wish to acknowledge the assistance of B. J. Sweo in various parts of the work done in this investigation.

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THE ANALYSIS OF FELDSPAR*

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ABSTRACT

The methods commonly used for the chemical analysis of feldspar require an excessive amount of time, particularly if the analysis is to be used only for grading the material and where great accuracy is not essential. More rapid methods are described for determining alumina, calcium oxide, and the alkalis. In these, alumina is determined by precipitating with 8-hydroxyquinoline in acid solution and then titrating an acid solution of the precipitate. Calcium oxide is determined by precipitating with oxalic acid without prior removal of aluminum and then titrating with standardized potassium permanganate. The alkalis are weighed as chlorides and potassium is determined by difference after sodium has been weighed as the triple acetate. Optional methods for attacking feldspar by acid instead of by fusion are described.

I. General Considerations

Determinations of silica, alumina, ferric oxide, and the alkalis suffice, ordinarily, for the purpose of classifying or grading a commercial feldspar. Calcium oxide and magnesia, which occur in small amounts only, are generally of minor importance and their determinations are required only in special instances.

Little or no opportunity affords itself to shorten the procedures for either silica or ferric oxide. Silica, if required, is best determined by the conventional method of double dehydration with hydrochloric acid following the fusion of the sample with sodium carbonate. Time can be saved, however, by preparing the fusion in the same dish in which the silica is to be dehydrated. The filtrate resulting from the determination of silica can well be used for other determinations, such as that of alumina, by precipitation with 8-hydroxyquinoline or the direct precipitation of calcium as oxalate. Ferric oxide is preferably determined by electrometric titration, although the colorimetric method may perhaps be more rapid. This latter method, as is well known, is subject to so many disturbing influences that reliable results can be expected only when the composition of the test solution and the standard solution are identical. Manifestly the preparation of solutions to meet these requirements offers little in comparison with other methods.

The determination of alumina by precipitating with 8-hydroxyquinoline in an acetic acid solution, dissolving the precipitate in hydrochloric acid, and titrating with a solution of potassium bromate-potassium bromide offers a procedure which is both accurate and rapid. Iron, titanium, and zirconium are precipitated by 8-hydroxyquinoline under the same conditions as is aluminum and will therefore be included with the latter. In general, they are not present in feldspars in sufficient quantities to influence seriously the determination of alumina. If they have been individually determined their effective percentages can be estimated and deducted.

The J. Lawrence Smith procedure is generally used for the determination of sodium and potassium oxides and involves a final separation of potassium either as the chloroplatinate salt or as potassium perchlorate. The former requires the use of an expensive reagent while the latter de-

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mands special washing solutions and certain corrections for solubility. Precipitation of sodium by zinc uranyl acetate affords a direct determination of this constituent and is attractive because the volumes of solutions are small, and filtration, washing, and drying are rapid.

The determination of calcium oxide, which is not a requirement of the commercial standard classification of feldspar,[1] may be of importance in special instances. Its determination is easily effected without prior removal of aluminum or iron by rendering the filtrate from a silica determination faintly acid, precipitating as oxalate, and titrating with potassium permanganate. Calcium oxide can also be determined in solutions of separate samples from which the silica has been eliminated by treatment with hydrofluoric and sulfuric acids.

TABLE I

RESULTS OBTAINED FOR Al_2O_3 IN COMMERCIAL FELDSPARS

Experiment No.	Al_2O_3 Present (%)	Al_2O_3 Found (%)	Al_2O_3 Difference (%)	Remarks
1	18.03	18.01	−0.02	Bur. Stand. standard sample No. 70
2	18.03	18.06	+ .03	" " " " " 70
3	18.03	18.02	− .01	" " " " " 70
4	19.06	19.10	+ .04	" " " " " 99
5	19.06	19.11	+ .05	" " " " " 99
6	19.06	19.14	+ .08	" " " " " 99
7	15.33	15.34	+ .01	Results given under "percentage present" in experiments 7 to 15 are the values reported by the analyst for a producer of commercial feldspar who used the standard method (double dehydration for silica and double precipitation with ammonium hydroxide) and who estimates that the values are accurate to ±0.2%.
8	15.33	15.33	.00	
9	18.75	18.75	.00	
10	18.75	18.72	− .03	
11	14.30	14.40	+ .10	
12	14.30	14.37	+ .07	
13	21.25	21.09	− .16	Results given under "percentage present" in experiments 13 to 15 may be high because of the presence of an appreciable amount of barium in the sample.
14	21.25	21.15	− .10	
15	21.25	21.12	− .13	

II. Experimental Work

(A) Determination of Alumina

The determination of alumina in feldspar, after the removal of silica, involves the separation of alumina from sodium and potassium oxides and small amounts of calcium oxide and magnesia. Under such conditions it is distinctly advantageous to precipitate the alumina from an acetic acid solution, buffered with acetate, by means of 8-hydroxyquinoline, dissolving the precipitate in hydrochloric acid and titrating with a standard solution of potassium bromate-potassium bromide. Preliminary experiments demonstrated that for accurate determinations the acidity of the solution containing the alumina must be carefully adjusted.

Solutions containing 15, 20, and 25 milligrams of alumina alone, when treated by the recommended procedure, gave 14.9, 19.9, and 24.8 milligrams, respectively. While slightly lower values are found in solutions of pure aluminum due to solubility of the precipitate, percentages obtained in the analysis of feldspar should be slightly high, partly because of the presence of small amounts of precipitable elements such as iron, titanium, and zirconium. In Table I are given the results obtained by the recommended procedure when applied to solutions obtained in the analysis of typical feldspars.

The figures in the second decimal place under "found (%)" indicate precision and not accuracy. In reporting determinations of this type, results should be rounded off to the nearest tenths, unless the analyst has average results obtained in a number of determinations that show no marked deviations from one another.

(1) Procedure Determinations of alumina by the following procedure should be made in solutions representing 0.1 gram of feldspar. These may be obtained by taking aliquot portions from the filtrate obtained in a silica determination or from a solution of the feldspar after treatment with hydrofluoric and sulfuric acids.

(2) Preparation of the Solution If silica has been determined in a 0.5-gram sample of feldspar, dilute the filtrate and washings to exactly 250 milliliters and

[1] Feldspar, Nat. Bur. Stand., Commercial Standard CS23-30 (1930).

treat a 50-milliliter aliquot by the given procedure.

If alumina only is to be determined, treat 0.5 gram of the sample (dried at 105 to 110°C) in a platinum dish with 5 milliliters of water, 25 milliliters of hydrofluoric acid (48%), and 10 milliliters of sulfuric acid (1 + 1)[2] and evaporate to fumes. Cool, dilute with 25 milliliters of water, and rinse the walls of the dish. Again evaporate to heavy fumes of sulfuric acid to insure complete expulsion of hydrofluoric acid. Dissolve the contents of the dish by adding 80 milliliters of water and 20 milliliters of hydrochloric acid and heating gently. Cool, transfer to a 250-milliliter graduated flask, and dilute to the mark. Fifty milliliters of the solution are treated by the following procedure.

If, in addition to alumina, calcium and magnesium oxides are to be determined, treat 2.5 grams of the feldspar (dried at 105 to 110°C) in a platinum dish with 10 milliliters of water, 65 milliliters of hydrofluoric acid (48%), and 25 milliliters of sulfuric acid (1 + 1), and evaporate to fumes of the latter. Cool, dilute with 50 milliliters of water, and rinse the walls of the dish. Again evaporate to heavy fumes of sulfuric acid. Cool and add 100 milliliters of water and 25 milliliters of hydrochloric acid. Warm until salts are dissolved. Cool, transfer to a 250-milliliter graduated flask, and dilute to the mark. A 10-milliliter aliquot of this solution representing 0.1 gram of feldspar is treated by the given procedure.

(3) Precipitation of the Alumina For the determination of alumina, dilute an aliquot, as obtained above, to 125 milliliters with water and treat with 0.2 gram of tartaric acid, 3 grams of ammonium acetate, and 4 drops of a 0.04% solution of brom cresol purple. Add diluted ammonium hydroxide (1 + 1) cautiously near the end, until a permanent distinct purple color appears (p_H, approximately 6.8). Quickly add 12 milliliters of a 2.5% solution of 8-hydroxyquinoline as the solution is vigorously stirred. Stir occasionally as the solution is heated to boiling and then boil gently for one minute. Allow to cool for 15 minutes. Filter through a Jena glass fritted crucible (IbG3) under moderate suction, or a 9-centimeter No. 42 Whatman or equivalent filter and wash thoroughly with 50 milliliters of water.

If a paper was used, sluice the precipitate into a 400-milliliter beaker and dissolve it, as well as that which adheres to the paper, by pouring through the latter 60 milliliters of hydrochloric acid (1 + 2). Wash the paper thoroughly with warm diluted hydrochloric acid (1 + 99). If a fritted crucible was employed, place the crucible and precipitate in 60 milliliters of hydrochloric acid (1 + 2), warm until solution is complete, and remove and wash the crucible. Replace the crucible on the filtration apparatus and thoroughly wash it with warm dilute hydrochloric acid to recover any solution held in the glass frit.

(4) Titration of the Precipitate Dilute the solution to 200 milliliters with water and cool to approximately 20°C. Add a standard 0.25 *N* solution of potassium bromate-potassium bromide until in 2- to 3-milliliter excess, as determined by test or by calculation if the approximate amount of alumina is known. If the bromate solution is 0.25 *N*, each milliliter is equivalent to 1.062 milligrams of Al_2O_3; hence for 25 milligrams of Al_2O_3, there would be needed 25 ÷ 1.062 = 23.5 + 2-milliliter excess, 25 to 26 milliliters. Stir and let stand for 30 to 60 seconds to insure complete bromination. Add 10 milliliters of a 20% solution of potassium iodide, stir thoroughly to make sure that reaction between the bromine and the iodide is complete, and then titrate with a 0.1 *N* solution of sodium thiosulfate until the color of the solution becomes a faint brownish yellow.

NOTE: In titrating the liberated iodine the addition of the thiosulfate is continued until the solution is a pale brownish yellow. Care in distinguishing between this color and the yellow color due to the brominated 8-hydroxyquinoline is necessary.

Add 2 milliliters of starch solution and titrate until the blue color disappears.

Subtract, from the volume of the potassium bromate-bromide added, the volume of potassium bromate-bromide solution which is equivalent to the volume of sodium thiosulfate solution that is required. Multiply the difference, representing the volume of potassium bromate-bromide consumed in reacting with the 8-hydroxyquinoline, by the titer of this solution to obtain the amount of alumina present.

In titrating quinolates with potassium bromate, 4-gram atoms of bromine are required for each

[2] Made by diluting one volume of sulfuric acid (specific gravity 1.84) with one volume of water. When no dilution is specified the use of a concentrated reagent is intended.

quinolate radical. Consequently 24-gram atoms of bromine represent one gram molecule of Al_2O_3 and 1 milliliter of an exactly 0.25 normal solution of the bromate-bromide should equal

$$\left(\frac{101.94}{24} \times \frac{1}{1000}\right) \div 4 = 0.001062 \text{ gram alumina.}$$

The theoretical titer of the bromate-bromide solution can be obtained by calculation after titration with a standard solution of sodium thiosulfate. In practice, it is more desirable to standardize the solution by means of weighed portions of a standard feldspar, which have been treated as described in the method, or weighed portions of pure aluminum.

The determination of alumina by precipitation with 8-hydroxyquinoline in acetic acid solution is subject to interference by such elements as iron, titanium, and zirconium. The alumina equivalents of these elements are approximately as follows:

$$1\% \ Fe_2O_3 = 0.6\% \ Al_2O_3$$
$$1\% \ TiO_2 = 0.4\% \ Al_2O_3$$
$$1\% \ ZrO_2 = 0.3\% \ Al_2O_3$$

Other elements, less likely to be encountered in feldspar, which are precipitated by 8-hydroxyquinoline in acetic acid solution are manganese, cobalt, nickel, copper, zinc, cadmium, molybdenum, tungsten, bismuth, uranium, and thorium.

The solutions that are required are prepared as follows:

8-Hydroxyquinoline Solution (2.5%). Treat 12.5 grams of 8-hydroxyquinoline with 25 milliliters of glacial acetic acid and warm gently to effect solution. Pour the resulting solution into 450 milliliters of water at 60°C. Cool, filter if necessary, and dilute to 500 milliliters. Although no attempt has been made to determine the stability of acetic-acid solutions of 8-hydroxyquinoline, solutions standing in the laboratory for a few weeks or a month have been found entirely satisfactory.

Potassium Bromate-Bromide Solution (0.25 N). Dissolve 6.96 grams of potassium bromate and approximately 25 grams of potassium bromide in 500 milliliters of water and dilute to 1000 milliliters. This solution is most conveniently standardized against accurately weighed dry samples, of approximately 0.1 gram, of the National Bureau of Standards standard sample of feldspar No. 70 which has been thoroughly decomposed and carried through all the steps of the procedure. This sample contains 18.03% of alumina. The solution may, if desired, be standardized against a standard solution of thiosulfate. This latter procedure requires much care and is not as satisfactory for commercial practice.

Sodium Thiosulfate Solution (0.1 N). Dissolve 25 grams of sodium thiosulfate ($Na_2S_2O_3 \cdot 5H_2O$) in 200 milliliters of water, add 0.1 gram of sodium carbonate, and dilute to 1000 milliliters. This solution is standardized against 0.1 *N* standard iodine solution only when it is to be used for determining the strength of the potassium bromate-bromide solution. The ratio between the solutions of potassium bromate-bromide and sodium thiosulfate is obtained as follows: To 160 milliliters of cool water containing 4 grams of potassium iodide, add 15 milliliters of the bromate solution. Stir, add 40 milliliters of cool hydrochloric acid (1 + 1), and titrate with the sodium thiosulfate solution until the solution is faintly yellow. Add 4 milliliters of starch solution and continue the titration until the blue color disappears. From the above ratio, calculate the potassium bromate-bromide equivalent of the thiosulfate solution by dividing the number of milliliters of potassium bromate-bromide by the number of milliliters of sodium thiosulfate used.

Starch Solution. Dissolve 5 grams of soluble starch and 2.5 grams of salicylic acid in one liter of water.

Potassium Iodide Solution (20%). Dissolve 25 grams of potassium iodide in 100 milliliters of water.

(B) Determination of Sodium and Potassium Oxides

The J. Lawrence Smith method for the determination of sodium and potassium oxides in feldspar requires far more time than need be expended to obtain satisfactory results for the purpose of grading or routine control. Improvements in the method lie in the rapid removal of silica, alumina, ferric oxide, calcium oxide, and magnesia. In the recommended procedure silica is removed by treating with hydrofluoric and either oxalic or perchloric acids, and then alumina, ferric oxide, and magnesia together with some calcium oxide are removed by precipitating with 8-hydroxyquinoline in ammoniacal solution and filtering. The weight of the combined alkali chlorides is then determined in the usual manner. If more than 0.1% of calcium oxide is present, it must be

removed as oxalate before the combined alkali chlorides are weighed. For the determination of sodium oxide, the alkali chlorides are dissolved in water and treated with zinc uranyl acetate, and the resulting precipitate of $(UO_2)_3ZnNa(CH_3COO)_9 \cdot 6H_2O$ is filtered out, washed, dried, and weighed.

In Table II are given the results obtained in analyses of commercial feldspars by the foregoing procedure.

In comparing results it should be noted that errors accumulate for the constituent which is determined by difference. In the J. Lawrence Smith procedure, in which potassium oxide is determined as potassium perchlorate or potassium chloroplatinate, errors are reflected in the values obtained for sodium oxide, whereas in the new procedure results obtained for potassium oxide are more likely to be subject to error. The figures in the second decimal place under "found (%)" are shown in order to indicate precision and not accuracy. In reporting determinations of this type, results should be rounded off to the nearest tenths unless the analyst has averaged results obtained in a number of determinations that show no marked deviations from one another.

TABLE II

RESULTS OBTAINED FOR Na_2O AND K_2O IN COMMERCIAL FELDSPARS

Experiment No.	Weight of mixed chlorides		Na_2O			K_2O		
	Present[1] (gram)	Found (gram)	Present (%)	Found (%)	Difference (%)	Present (%)	Found (%)	Difference (%)
1*	0.0209	0.0210	10.73	10.75	+0.02	0.41	0.44	+0.03
2*	.0209	.0211	10.73	10.70	− .03	.41	.57	+ .16
3*	.0209	.0209	10.73	10.73	.00	.41	.44	+ .03
4*	.0209	.0209	10.73	10.76	+ .03	.41	.38	− .03
5†	.0244	.0244	2.38	2.39	+ .01	12.58	12.57	− .01
6†	.0244	.0245	2.38	2.40	+ .02	12.58	12.63	+ .05
7†	.0244	.0242	2.38	2.47	+ .09	12.58	12.38	− .20
8†	.0244	.0242	2.38	2.44	+ .06	12.58	12.38	− .20

[1] Weight of mixed chlorides present in 0.1-gram samples as calculated from values given for Na_2O and K_2O in the certificate of analyses.

* Nat. Bur. Stand. standard sample No. 99.

† Nat. Bur. Stand. standard sample No. 70.

(1) Procedure Treat 0.1 gram of the sample, dried at 105 to 110°C, in a small platinum dish with 2 to 3 milliliters of water, 10 milliliters of hydrofluoric acid (48%), and 1 milliliter of hydrochloric acid and evaporate to dryness on a steam bath. Moisten the residue with 2 to 3 milliliters of water, add 0.5 gram of oxalic acid and heat to dissolve the latter. Evaporate to dryness and ignite cautiously for a few minutes, not exceeding dull redness. Allow the dish and contents to cool, add 2 milliliters of water and 0.5 gram of oxalic acid, and repeat the evaporation and ignition.

NOTE: The following optional procedure may be employed for decomposing the feldspar. Treat 0.1 gram of the dried sample with 10 milliliters of hydrofluoric acid (48%), 1 milliliter of hydrochloric acid, and 0.3 milliliter of perchloric acid (60 to 70%). Evaporate to dryness and expel the excess of perchloric acid by heating on a hot plate. Cover the dish with a watch glass and continue the heating by brushing with a free flame until the perchlorates are converted to chlorides, avoiding a temperature in excess of momentary dull redness. Cool, and proceed as in the method given above.

In either procedure especial care must be taken to insure representative material on account of the small sample that is taken.

Cool, drench the residue with 2 milliliters of hydrochloric acid, add 25 milliliters of water, and heat to effect solution of soluble salts. Transfer the solution to a 150-milliliter beaker and dilute to 45 milliliters. Add 12 milliliters of a 2.5% solution of 8-hydroxyquinoline in 5% acetic acid. Heat the solution nearly to boiling and slowly add ammonium hydroxide with constant stirring until the solution is alkaline to litmus. If barium is believed to be present add a few drops of an ammonium carbonate solution. Boil gently for one to two minutes. Allow the precipitate to settle, filter, and wash with diluted ammonium hydroxide (1 + 99) containing a little 8-hydroxyquinoline, catching the filtrate and washings in a 100-milliliter platinum dish. Evaporate the filtrate and washings to dryness and ignite gently until ammonium salts are expelled and carbonaceous matter is destroyed. Moisten the residue with 2 or 3 drops of HCl and add 2 milliliters of water. Transfer the solution to a 50-milliliter beaker and dilute to 10 milliliters. Add 0.1 gram of ammonium oxalate, heat to boiling, and add

ammonium hydroxide until faintly ammoniacal. Filter the precipitated calcium oxalate through a 7-centimeter S & S No. 589 blue band or equivalent filter and wash thoroughly with small portions of cold 1% solution of ammonium oxalate. Evaporate the filtrate and washings in a weighed platinum dish until dry and gently ignite to remove ammonium salts and destroy organic matter. Dissolve the residue in a few millilite.s of water and add a few drops of hydrochloric acid to destroy carbonates. Evaporate to dryness and when dry cover with a watch crystal and *cautiously* ignite at a temperature not higher than 500°C. Cool in a desiccator for 30 minutes and weigh as NaCl + KCl.

(2) Determination of Sodium Oxide During the determination of sodium oxide either marked temperature changes or concentration of the reagent by evaporation should be avoided if satisfactory results are to be obtained. It is imperative, therefore, that the precipitation, filtration, and washing of the precipitate be carried out at some uniform temperature, *e.g.*, 24 ± 1°C.

Dissolve the mixed alkali chlorides in 1 milliliter of water and add 15 milliliters of zinc uranyl acetate reagent. Allow to stand for at least 2 hours. Stir thoroughly and quickly pour the solution into a weighed 35-milliliter Jena glass fritted crucible (No. 1bG4) which has previously been moistened with a few drops of the reagent and which is kept under moderate suction.

Wash and completely transfer the precipitate to the crucible, using eight to ten 2-milliliter portions of the reagent and allowing each portion to drain completely before the succeeding portion is added. Wash the crucible and precipitate five to ten times with 2-milliliter portions of washing alcohol and finally with ether. Remove the ether by drawing air through the crucible. Wipe with a damp cloth, place in a desiccator, and weigh at the expiration of ten or more minutes.

$$\frac{\text{Weight of } (UO_2)_3ZnNa(CH_3COO)_9{\cdot}6H_2O \times 0.02015}{\text{Weight of sample}} \times 100 = \% \; Na_2O$$

$$\text{Weight of } (UO_2)_3ZnNa(CH_3COO)_9{\cdot}6H_2O \times 0.038 = \text{weight of NaCl}$$

The zinc uranyl acetate reagent is prepared from the following solution:

		Grams
(A)	$UO_2(CH_3COO)_2{\cdot}2H_2O$	10
	Acetic acid 30%	6
	Water to make	65
(B)	$Zn(CH_3COO)_2{\cdot}3H_2O$	30
	Acetic acid 30%	3
	Water to make	65

After the salts in A and B have been dissolved by warming, the solutions are mixed and allowed to stand 24 hours. If no precipitation occurs a few milligrams of sodium chloride should be added to make sure the solution is saturated with uranyl-zinc-sodium acetate. To avoid the use of undersaturated solution it is recommended that the reagent be kept in contact with uranyl-zinc-sodium acetate and filtered from the latter just prior to use.

The washing alcohol is prepared by saturating 95% ethyl alcohol with uranyl-zinc-sodium acetate.

(3) Determination of Potassium Oxide This constituent is obtained by multiplying the weight of the uranyl zinc sodium acetate found in the determination of sodium oxide by 0.038 and deducting the weight of NaCl thus found from the combined weight of NaCl + KCl. The remainder, multiplied by 63.17 and divided by the weight of the sample, is taken as the percentage of potassium oxide in the feldspar.

(C) Determination of Calcium Oxide

Determinations of calcium oxide are almost invariably made by precipitating as oxalate after silica, iron oxide, alumina, etc., have been removed. In some methods attempts have been made to precipitate calcium oxalate in the presence of iron and aluminum by keeping the latter in solution by means of citrate or tartrate. Such procedures may lead to low results. For example, in two experiments involving 2 and 10 milligrams of calcium oxide in solutions containing one gram of citric acid in a volume of 100 milliliters, no precipitate was observed with the smaller amount and the precipitate obtained with the larger amount represented only two-thirds of the quantity present.

In the recommended procedure, silica is removed and the solution then treated with oxalic acid and nearly, but not completely, neutralized with ammonium hydroxide. After filtration and washing, the precipitate is dissolved in dilute sul-

furic acid and titrated with standard potassium permanganate. Solutions which contained 0.9, 2.9, and 5.4 milligrams of CaO when treated by this procedure yielded 0.6, 2.7, and 5.2 milligrams, respectively.

(1) Procedure Add 1 gram of oxalic acid to a 100-milliliter aliquot portion of a solution prepared as described in the procedure for the determination of alumina. If the amount of lime to be determined is less than 1.0 milligram the aliquot should be evaporated to a volume not exceeding 50 milliliters. Add 4 drops of a 0.04% solution of brom cresol purple and nearly neutralize (p_H about 4) with ammonium hydroxide. Heat to boiling and cautiously add dilute ammonium hydroxide (1 + 2) until the indicator just becomes a distinct purple. Boil the solution three minutes and allow the precipitate to stand one hour. Filter through a 7-centimeter S & S blue band No. 589 or equivalent, wash beaker and paper, and precipitate thoroughly with small portions of water. Sluice the precipitate into the beaker in which the precipitation was effected and pour 100 milliliters of warm sulfuric acid (2.5 + 97.5) through the filter to dissolve any adhering precipitate. Heat the solution to 80 to 90°C and titrate with standard 0.05 *N* potassium permanganate in the customary manner.

The percentage of calcium oxide is obtained by multiplying the number of milliliters of potassium permanganate consumed in the titration by 0.001402, dividing the product by the weight of the sample, and multiplying by 100.

(D) Determination of Magnesia

In general, magnesia occurs in such small quantities in feldspar that its determination should not be attempted with samples weighing less than 0.5 gram. Determinations can be made by precipitation as phosphate or quinolate in solutions from which iron, aluminum, and calcium have been removed. Methods in which citrate is added and magnesia is precipitated as phosphate in the presence of iron, aluminum, etc., are not recommended because it is difficult to precipitate the small amounts of magnesium that are involved.

(1) Procedure Take a 100-milliliter aliquot portion (representing 1 gram of sample) of the solution prepared as described under the determination of alumina, or the filtrate resulting from the determination of silica, and remove iron, aluminum, and calcium in the usual manner by precipitating twice with ammonium hydroxide and then precipitating once with ammonium oxalate in the combined filtrates. Acidify the resulting filtrate and concentrate to 100 milliliters. Cool, add 1 gram of diammonium hydrogen phosphate, and precipitate in the customary manner. Wash the precipitate with cold ammonium hydroxide (5 + 95), ignite, and weigh as magnesium pyrophosphate.

As a rule the percentage of magnesia in feldspar is so small that gravimetric or volumetric determinations by the use of 8-hydroxyquinoline[3] are not very satisfactory. The presence of any notable amount of magnesia can be qualitatively established by adding a slight excess of ammonium hydroxide to the filtrate obtained from the precipitation of alumina as the quinolate.

NATIONAL BUREAU OF STANDARDS
WASHINGTON, D. C.

[3] (*a*) J. C. Redmond and H. A. Bright, "Determination of Magnesium in Portland Cement and Similar Materials by the Use of 8-Hydroxyquinoline," *Bur. Stand. Jour. Research*, **6**, 113 (1931); R.P. 265.
(*b*) J. C. Redmond, "The Precipitation and Titration of Magnesium Oxyquinolate in the Presence of Calcium Oxalate, and Its Application in the Analysis of Portland Cement and Similar Silicates," *ibid.*, **10**, 823 (1933); R. P. 569.

CERAMIC ABSTRACTS[1]

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Abrasives

Balancing polishing wheels and drums. Fred B. Jacobs. *Metal Cleaning & Finishing*, **6** [11], 583–84 (1934).—To perform its best work, a polishing wheel must be in almost perfect balance. Polishing wheels can be balanced by either static or dynamic balancing. Several examples of dynamic balancing are cited. Illustrated. E.J.V.

Determining surface smoothness of work pieces and their susceptibility to smoothing. E. Franke. *Oberflächentechnik*, **11** [22], 249–51 (1934).—A new method to determine smoothness is described in which the pull which moves a gliding piece of definite weight over the surface is measured; the gliding piece is of highly polished glass. Instead of pulling the gliding piece, the angle under which the work piece can be tilted before the gliding piece begins to slide down may be determined. The angle is a measure of smoothness. A few measurements with alloy steels are described. M.H.

Polishing and buffing of aluminum. Anon. *Metal Cleaning & Finishing*, **6** [12], 635–36 (1934).—For roughing, a 12- to 20-in. rag or canvas wheel operating at a peripheral speed of about 6000 ft./min., coated with No. 60 to No. 100 powdered emery (or other fast cutting abrasive), and lubricated with tallow or similar lubricant is used. For "oiling," felt wheels faced with No. 100 to No. 160 abrasive, lubricated with heavy oil, and operating at 6000 ft./min. are best. In buffing, a softer wheel made of stitched linen disks, run at 7000 to 7500 ft./min., with tripoli type abrasives applied loosely to the surface, and lubricated with stearic acid and tallow serves well. For "coloring," an open wheel run at 7500 to 8000 ft./min. and using silica compounds, Vienna lime, or rouge mixed with a grease base is required. E.J.V.

PATENTS

Abrading machine. C. L. Mattison and L. T. Medholdt (Mattison Machine Works). U. S. 1,986,005, Jan. 1, 1935.

Abrasive saw tooth. Fred Bley (Martin Hoerer). U. S. 1,985,972, Jan. 1, 1935.

Abrasive wheel. H. R. Simonds (Simonds Worden White Co.). U. S. 1,986,648, Jan. 1, 1935. The abrasive wheel is balanced with a coat of paint applied in a limited area of one or both faces, on its light side.

Agent for polishing, sharpening, and grinding articles of great hardness. Reinhold Reichmann (Siemens & Halske A.-G.). U. S. 1,984,841, Dec. 18, 1934. The abrasive material consists principally of sintered beryllium oxide of a high degree of purity.

Cutlery grinding and polishing machines. B. Walters and W. M. Dobson. Brit. 419,536, Nov. 28, 1934.

Flexible abrasive articles such as sandpaper and method of making. A. H. Stevens (Minnesota Mining & Mfg. Co.). Brit. 419,811, Dec. 5, 1934.

Gear finishing generating machine. E. W. Miller (Fellows Gear Sharper Co.). U. S. 1,984,194, Dec. 11, 1934.

Grinding machine. Clement Booth (Cincinnati Grinders, Inc.). U. S. 1,985,237, Dec. 25, 1934. C. W. Hopkins (Cincinnati Grinders, Inc.). U. S. 1,983,853, Dec. 11, 1934. C. B. Schafer (Libbey-Owens-Ford Glass Co.). U. S. 1,986,537, Jan. 1, 1935. The apparatus is adapted to grinding the edges of glass sheets. Albert Turner (Cincinnati Grinders, Inc.). U. S. 1,985,433, Dec. 25, 1934.

Grinding, sanding, polishing, finishing, etc., blocks. W. E. Tollworthy and L. F. Murray. Brit. 420,239, Dec. 12, 1934.

Grinding wheel. A. P. Beebe (Peninsular Grinding Wheel Co.). U. S. 1,984,050, Dec. 11, 1934. A grinding wheel comprises a backing member including a disk of thin sheet metal and a plurality of annular members of thin strip metal each secured at an edge thereof to the disk and embedded in a disk of abradant material. Thure Larsson (Norton Co.). U. S. 1,984,936, Dec. 18, 1934.

Helical gear grinding machine. E. E. Eaton (Spicer Mfg. Corp.). U. S. 1,984,259, Dec. 11, 1934.

Lapping machine. W. P. Hunt (Hutto Engineering Co., Inc.). U. S. 1,984,374, Dec. 18, 1934.

[1] The bold-face number following the journal is the volume, the issue number is in brackets, followed by the page numbers, then the year in parentheses.

The abbreviation (*R.C.C.S.*) at the end of an abstract indicates that it was obtained from the *Reports of the Czechoslovakian Ceramic Society.*

Material, and bodies formed therefrom, for polishing, smoothing, and grinding very hard objects, particularly hard alloys. SIEMENS & HALSKE A.-G. Brit. 419,744, Nov. 28, 1934.

Method and apparatus for polishing cylinders. J. W. OFFUTT (National Tube Co.). U. S. 1,986,745, Jan. 1, 1935.

Method and means for grinding or abrading articles. CRAVEN BROS. (Manchester), LTD., J. R. GREENWOOD, AND A. G. WALLS. Brit. 420,441, Dec. 12, 1934.

Twist drill and method and device for grinding twist drills. WESSELMANN-BOHRER CO. A.-G. AND J. BECKMANN. Brit. 419,698, Nov. 28, 1934.

Art and Archeology

Antique dealers' fair. ANDREW CARFAX. *Connoisseur*, **94** [397], 180–89 (1934).—Bow and Chelsea ware, Chinese porcelain, Irish glass, etc., are illustrated. E.B.H.

Bingham, potter of Castle Hedingham. I. HENRY CLAY. *Connoisseur*, **94** [396], 120–23 (1934).—C. describes the small pottery of Edward Bingham and illustrates some of his more ambitious pieces, which indicate through their decoration his desire to impart information and education. **II.** *Ibid.*, **94** [397], 161–64 (1934).—Edward Bingham and his son made honest signed copies of medieval and ancient pottery thus stimulating interest in archeology. Illustrated. E.B.H.

Ceramic sculpture of Russell Aitken. GEOFFREY ARCHBOLD. *Design*, **36** [6], 17–19 (1934).—Russell Aitken is an outstanding potter and an original ceramic sculptor of national reputation. His most important work has been in ceramic sculpture caricature, especially with animal subjects. They are conceived in naturalistic manner with very little stylization and none of the arbitrary surface decoration often misused in this medium. A late piece is a highly stylized wheel-thrown *bonbonnière* showing a marked influence of Negro sculpture. Illustrated. E.B.H.

Colored etchings on tile. ANON. *Chambers' Jour.*, p. 800 (Oct., 1934).—Etchings by Donald Maxwell are reproduced in color on tile by the Doulton Co. H.H.S.

Connoisseur in America. HELEN COMSTOCK. *Connoisseur*, **94** [400], 392–97 (1934).—Italian majolica for the Nelson Gallery of Art in Kansas city is described. A rare signed piece of Giorgio of Gubbio, dated 1530, is executed in faience colors with the ruby luster for which he was famous. A pair of albarelli or drug jars were also acquired which perpetuate the shape of the segment of bamboo in which spices were received from the Orient. Illustrated. See also "De Forest Collection," *Ceram. Abs.*, **14** [2], 29 (1935). E.B.H.

Early American stoneware craftsmanship. CARLTON ATHERTON. *Design*, **36** [6], 14–15 (1934).—Illustrated. E.B.H.

Easy turning and firing methods for the amateur potter. R. H. JENKINS. *Design*, **36** [5], 18–21 (1934). E.B.H.

Faenza. R. BARTA. *Stavivo*, p. 327 (1933).—Faenza is the center of Italian ceramic school education and historical research on ceramics. It has an international ceramic museum. Since 1250 *mezza-majolica, i.e.*, a lead-glazed ware with the glaze applied to the unfired body, has been produced there. The origin of the lead-zinc glazed faience ware, the name of which was derived from Faenza, reaches back to the 14th Century. During the 15th and 16th Centuries about 40 plants were at work at Faenza. At that time not only decorated ware, but also undecorated tableware was produced here. In the 15th Century religious fanatics who emigrated from Faenza to Czechoslovakia exerted a great influence on the native ceramics not only in Moravia and Slovakia but also in Bohemia. Thus the beautiful blue, painted whiteware, which was produced in southern Bohemia during the 16th to 18th Centuries, in many ways resembles the "brettino" from Faenza. In the author's opinion, the native ceramic ware manufactured by Slovakian shops at present is no real faience, but only a "pseudofaience," as the body is not a pure white. R.B.(*R.C.C.S.*)

Lost city of Mari found in Syrian desert. ANDRÉ PARROT. *Illus. London News*, **185**, 544–47 (1934).—Discoveries by the Louvre Museum have uncovered further information on the Semites and Sumerians in Mesopotamia. H.H.S.

Mosaics of St. Sophia. STANLEY CASSON. *Art*, **27** [12], 634–40 (1934).—The cleaning of the mosaics of the church of St. Sophia at Constantinople may cause revised views of Byzantine painting and mosaics. The technical skill of the mosaic workers is beyond cavil. An ordinary craftsman could manage merely to fill gaps with tesserae, but here the tesserae follow lines, delineating surface molding, expression, etc., by subtle adjustments. Illustrated. See also *Ceram. Abs.*, **13** [5], 109 (1934). E.B.H.

Porcelain figures modeled by Bustelli at Nymphenburg. C. L. ROBERT. *Connoisseur*, **94** [400], 372–74 (1934).—Nymphenburg and many other German porcelain factories owed success to Ringler, the chemist who experimented and produced the unusually fine glazing distinctive of the small, finely modeled figures of Bustelli. His subjects were grouped as society, professional, etc., the Italian comedy group being one of the finest series produced in Europe during the rococo. Marks such as initials or a shield sometimes impressed in the paste and sometimes painted in blue under the glaze but always very small, identify the pieces. Illustrated. E.B.H.

Stiegel glassware. ANON. *Design*, **36** [6], 23 (1934).—Stiegel glass, first made at Lancaster, Pa., in 1763, was made in a variety of colors, some etched and some enameled. Illustrated. E.B.H.

Treasure-trove for Hull Museum. ANON. *Connoisseur*, **94** [398], 270–71 (1934).—This article describes ware discovered behind paneling probably put there about 1740. A basin of English Liverpool or Lowestoft ware, a posset pot of Nottingham ware, a large plate of Lambeth delft, two saucers of the Chinese blue and white K'ang Hsi, and a teapot of salt glaze of a rare type were presented to the Hull Museum by A. A. Walters. Illustrated. E.B.H.

Vases in the Hurlbutt collection. FRANK HURLBUTT. *Connoisseur*, **94** [398], 240–44 (1934).—The following vases are included: (1) a Bow vase in the Palissy style with decorations of molded lizards and snails, *i.e.*, the penciled forms between, (2) a hexagonal Chelsea vase and cover of the red anchor period decorated in the Kakiemon manner, brilliant in red, blue and green, and yellow enamel, (3) a Worcester hexagonal vase and cover painted with the Kakiemon pattern of the Flying Fox, (4) Derby bracket vase in rococo style, (5) a Bow vase, rococo run amok, (6) a garniture of three Worcester vases with covers and two beakers, of blue green translucency, with painted birds, (7) a pair of jardinières, Church Gresley, of vivid canary ground diapered in red, (8) a pair of Derby Campana-shaped vases of peach bloom ground relieved with fine burnished gilding, (9) a set of three early Derby vases with covers with decided Oriental influence, and (10) a set of three Swansea vases of Billingsley's paste and glaze decorated with the old Derby three-rose pattern. Illustrated. E.B.H.

BOOK

Artistic Finishing of Crockery for Wide Consumption. Symposium edited by A. W. PHILIPPOV. States Acad. Arts, Moscow and Leningrad, 1932. This symposium describes the fundamental principles of the artistic finishing of crockery for practical purposes with the intention of attracting public opinion to this problem.

P. P. BUDNIKOFF

PATENTS

Designs for:

Bathroom fixture. CARMEN DI ANTONIO. U. S. 94,192, Jan. 1, 1935.

Bottle. E. W. FUERST (Owens-Illinois Glass Co.). U. S. 94,199, Jan. 1, 1935. H. R. MCDONALD (Hart Glass Mfg. Co.). U. S. 94,230, Jan. 1, 1935. G. A. MENGLE (Wizard, Inc.). U. S. 94,231, Jan. 1, 1935. FRASIER SMITH (Hazel-Atlas Glass Co.). U. S. 94,246, Jan. 1, 1935. J. S. STEELMAN (Whitall-Tatum Co.). U. S. 94,170, Dec. 25, 1934.

Combined jar and closure. M. S. DESSER (Owens-Illinois Glass Co.). U. S. 94,021, Dec. 11, 1934.

Dish. J. M. STANGL (Fulper Pottery Co.). U. S. 94,169, Dec. 25, 1934.

Glass bottle. R. G. TWIGGS (J. T. & A. Hamilton Co.). U. S. 94,250 and 94,251, Jan. 1, 1935.

Jar. E. W. FUERST. U. S. 94,198, Jan. 1, 1935. T. J. PIAZZOLI (Capstan Glass Co.). U. S. 94,095, Dec. 18, 1934.

Plate. F. H. SEBRING, JR., AND DONALD SCHRECKENGOST. U. S. 94,245, Jan. 1, 1935.

Tea warmer, etc. E. M. BOTTOME (Fostoria Glass Co.). U. S. 94,182, Jan. 1, 1935.

Tumbler. R. D. SPEAR (Hazel-Atlas Glass Co.). U. S. 94,100, Dec. 18, 1934.

Cements

Acid-proof cements. UNITED STATES STONEWARE CO. *Metal Cleaning & Finishing*, **6** [11], 585 (1934).—"Pre-Mixt" is ready mixed, acid-proof, and water-proof cement which requires only the admixture of water. With an initial set of 1 hr. and final set in 24 to 36 hr. it produces thoroughly acid-proof and water-proof joints. The hardening action is purely chemical, not being dependent upon drying in air. E.J.V.

Constitution of Portland cement and aluminous cement. A. TRAVERS. *9th Internat. Congress of Pure and Applied Chem.*, pp. 67–133 (1934); abstracted in *Chim. & ind.*, **32** [4], 854 (1934); *Ind. chimique*, **21** [246], 492 (1934).—This is a detailed study of real and supposed constituents of cements: silicates, aluminates, ferrites of lime, complex compounds, etc. Clinker contains tricalcium silicate, brownmillerite, tricalcium aluminate, or dicalcium ferrite, and free lime. Fused cement is chiefly composed of monocalcium aluminate and dicalcium silicate. The hydration of these materials leads either to an ordinary combination of the water and of the anhydrous material (as in the case of tricalcium aluminate) or to a decomposition followed by the formation of hydrated salts, less basic (silicates) or more basic (aluminates). With respect to hydroaluminates of calcium, the existence of simple compounds and of solid solutions was established; the crystalline forms are in relation with the p_H of the medium. The difference between some aluminates is explained by their derivation from two aluminous acids, $Al(OH)_3$ and AlO_2H. The hydration of clinker yields mostly hydrated tricalcium disilicate and tricalcium aluminate (or even more basic); it is limited to grains that are not so thick, and the setting has a colloidal character. The hydration of fused cement produces hydrated alumina and hydrated basic aluminates. The setting affects all the grains and presents a crystalline character. The addition of gypsum to the clinker slows down setting because of the formation of the sulfoaluminate of Candlot, slightly soluble in a p_H medium > 11.7. The same sulfoaluminate, formed by the action of selenitic water on fused cement, explains its resistance to these waters. M.V.K.

Effect of magnesia content in Portland cement clinker on ferrites of tetracalcium aluminate. A contribution to the system CaO–MgO–Al_2O_3–Fe_2O_3. H. E. SCHWIETE AND H. ZUR STRASSEN. *Zement*, **23**, 511–14 (1934); abstracted in *Chem. Zentr.*, ii, 2878 (1934). M.V.K.

Heat of formation of monocalcium silicate from gypsum and silica. OTTO FR. HONUS. *Zement*, **23**, 415–19 (1934); abstracted in *Chem. Zentr.*, ii, 3161–62 (1934). M.V.K.

Hydrates of calcium silicates. HANS KÜHL AND ALEXANDER MANN. *Tonind.-Ztg.*, **58** [71], 862–65; [73], 896–97; [75], 918–19; [76], 930–32; [77], 944–45; [78], 955–57; [81], 990–91; [82], 1003; [83], 1014–16 (1934).—The course of reaction of various silicate melts in contact with calcium hydroxide solutions was investigated. The CaO part of the melts amounted to 0.0 to 2.0 CaO mol. (calculated to 1 SiO_2 mol.). It is shown that one hydrate of calcium silicate poor in lime, such as the $CaO{\cdot}SiO_2{\cdot}aq.$, is stable in limewater which contains 0.131 g. CaO/liter.

The formation of a series of gel-like hydrates of calcium silicates is discussed; their formation begins in the composition CaO·SiO·aq. and extends to the composition $2CaO·SiO_2·aq$. The concentration of the limewater determines the composition of the gel, which originates during the hydration of calcium silicate melts with more than 1 mol. CaO to 1 mol. SiO_2. The determination that the gel of the hydrate of calcium silicate is stable in the presence of saturated limewater is important for the chemistry of cement. M.V.K.

Investigation of commercial masonry cements. JESSE S. ROGERS AND RAYMOND L. BLAINE. *Jour. Research Nat. Bur. Stand.*, **13** [6], 811–49 (1934); R.P. 746. Price 5¢.—Forty-one commercial masonry cements were studied with respect to chemical composition, fineness, weight per unit volume, volumetric flow of the neat pastes, and bulk specific gravity, while mortars made from those cements were studied with respect to resistance to deformation, water-retaining capacity, volume, yield, linear changes, compressive and transverse strength, efflorescence, durability when subjected to cycles of freezing and thawing, and absorption. R.A.H.

Enamels

Adjustment of enamels to sheet steel. A. DIETZEL AND K. MEURES. *Jour. Amer. Ceram. Soc.*, **18** [2], 37–38 (1935).

Antimony anhydride in enameling. ANON. *Verre & Silicates Ind.*, **5** [20], 388–89 (1934).—The properties of antimony anhydride, Sb_2O_3, and its wet and dry manufacture are given. The danger from poisoning if Sb_2O_3 is used in enamelware is exaggerated. M.V.K.

Apparatus for testing enameled ware. L. VIELHABER. *Emailwaren-Ind.*, **11** [45], 369–70 (1934).—A brief description is given of American apparatus used for testing the properties of enamels. M.V.K.

Black enamel directly on iron. ANON. *Glashütte*, **64** [34], 573–75 (1934).—Attempts to produce a leadless enamel are discussed in detail. The best results were obtained with an enamel whose analysis is 30.1 silica, 8.7 lead oxide, 24.4 barium oxide, 6.6 sodium silico-fluoride, 9.1 sodium oxide, 12.2 boric acid, 1.3 cobalt oxide, and 2.6 manganese oxide. The enamel had a fine luster and a black color tone. Special care was taken of the cast iron to insure a satisfactory enamel. M.V.K.

Calculating tensile strength of enamel. ANON. *Emailwaren-Ind.*, **11** [44], 365 (1934).—The calculation is explained. M.V.K.

Continuous enameling furnace. VII. F. S. MARKERT. *Enamelist*, **12** [2], 14–15 (1934).—In equipping the furnace with tools for holding ware during the firing many designs had to be worked out to accommodate the different shapes and types of ware. The most modern tools are predominantly castings though some are fabricated from rolled sections, and hooks, etc., are made of drawn wire. Nickel-chromium alloys have been found best for such tools. Analyses are given for these alloys. Illustrated. For Part VI see *Ceram. Abs.*, **14** [2], 31 (1935). E.J.V.

Diary of an enamel technician in 1830. O. SCHILLING AND W. KERSTAN. *Glashütte*, **64** [31], 511–13; [39], 650–52 (1934).—The composition of various enamel batches, their working, and the enameling of cast-iron ware are described. M.V.K.

Economy in the use of borax. L. VIELHABER. *Emailwaren-Ind.*, **11** [41], 338–39 (1934).—The possibilities of a partial replacement of borax by other materials without lowering the quality of enamels are discussed. Several compositions are analyzed. M.V.K.

Effect of annealing on reboiling of porcelain enamels. J. J. CANFIELD. *Bull. Amer. Ceram. Soc.*, **14** [1], 13–14 (1935).

Effect of saltpeter in enamel. ANON. *Glashütte*, **64** [28], 467–69 (1934).—Various experiments to determine the effect of saltpeter in enamels are discussed. It was found that an addition of up to 5% saltpeter is sufficient. In enamels which contain larger amounts of metallic oxides and which are fused in oil furnaces, it is recommended to introduce an oxidation agent which disintegrates only at higher temperatures. Two oxidation agents having a different temperature of dissociation can be successfully used. In this case barium is recommended because of its high refractive index which increases luster and the appearance of the enamel. M.V.K.

Enameling cast iron according to the immersion method. L. VIELHABER. *Emaillerie*, **2** [3], 21–27 (1934); abstracted in *Emailwaren-Ind.*, **11** [44], 367 (1934).—The addition of quartz must be avoided because the enamel must be of a comparatively low melting point. Calcite is added to harden the enamel. About 10% opacifiers are required. Zinc oxide improves luster. About 3% saltpeter is used to oxidize the iron and organic materials. Cryolite strengthens the opacifying effect of antimony oxides; in this case lime or baryta is added. The melting point can be lowered by large additions of borax or soda. The coefficient of expansion of the enamel must be lower than that of cast iron, 280 or 290 against 300×10^{-7}. Its composition should be adapted to the iron. The average composition of the enamel is 30 to 40 feldspar, 0 to 5 quartz, 25 to 35 borax, 3 to 4 saltpeter, 6 to 12 zinc oxide, 3 to 6 fluorspar, 6 to 10 soda, 0 to 5 calcite, 0 to 6 magnesia, 0 to 2 cryolite, and 3 to 6% barium carbonate. The granules are heated to dryness and liberated from dust by sifting. The hot cast-iron pieces are inserted into the heaped enamel and kept in it for 0.5 to 1 min. The exact time is easily determined experimentally. M.V.K.

Enamels, yesterday and today. H. EDWARD WINTER. *Enamelist*, **12** [3], 16–17 (1934).—W. traces the development of the art of enameling from the Egyptians to the present day. The five types of enamels discussed are cloisonné, champlevé, *basse-taille*, *plique a jour*, and painted enamel. The possibilities of enamel in future architecture are evidenced by huge enamel plaques in the Music Hall at Radio City, New York, and in murals being made for large manufacturing concerns, as well as in enamel buildings such as were exhibited at the Chicago Century of Progress Exposition. E.J.V.

Firing brick in annular kilns with wood. FR. ONDRUŠ. *Stavivo*, p. 311 (1933).—As the price of wood is very low

in Czechoslovakia, many brickworks are again using it for firing. The flame is long and therefore a part of the holes must not be fired at all. The fires only need to be charged every hour. The temperature may be raised faster, the fire progresses farther (18 chambers instead of 14), and the cost is about one-third as much as coal. No clinker is formed and the danger of ash on the ware is avoided. Scum is not formed as the gas is free of sulfur.
R.B.(*R.C.C.S.*)

Heat in the enamel industry. A. W. BRUINS. *Emaillerie*, **2** [4], 5–17 (1934); abstracted in *Emailwaren-Ind.*, **11** [44], 367 (1934).—Sources of heat and the factors determining the heat exchange are discussed. M.V.K.

Hospitals for enamelware. FRANK R. PORTER AND A. S. AULT. *Enamelist*, **12** [3], 13 (1934).—Operation of a "hospital," a small department operated by one man to salvage all ware possible, decreases the percentage of ware for de-enamel or scrap, and with a competent workman in charge, aided by carefully trained inspectors, it more than pays for itself in savings. E.J.V.

Majolica enamels. A. W. *Emaillerie*, **2** [3], 5–10 (1934); abstracted in *Emailwaren-Ind.*, **11** [44], 367 (1934).—A discussion is given of various possibilities of enameling, especially from the viewpoint of economy in the number of firings and difficulties that leadless enamel may cause with the powder method. M.V.K.

Masterpieces in enamel craftsmanship in recent exhibit of H. Edward Winter. HARRY E. MARTIN. *Enamelist*, **12** [2], 11–13 (1934).—Brief descriptions of pieces of artistic enamel exhibited at the Bentley-Coulter Gallery of Cleveland, Nov., 1934, are given. Illustrated. See also "Enameler, etc.," *Ceram. Abs.*, **13** [10], 250 (1934). E.J.V.

Meeting of the English Enamel Technical Society. L. VIELHABER. *Emailwaren-Ind.*, **11** [46], 377–80 (1934).—A brief discussion is given of papers read at the meeting held at Birmingham in February, 1934. M.V.K.

Microscopic observations on the appearance of enamels during firing and reboiling. A. I. ANDREWS. *Bull. Amer. Ceram. Soc.*, **14** [1], 18–19 (1935).

Modern art in porcelain enamel. ANON. *Better Enameling*, **5** [11], 14–15 (1934).—A brief description of the process of making Limoges enamelware, as practiced by Molli Juin of San Francisco, is presented. Illustrated. E.J.V.

Once-fired, single coat enamel tubs in green and blue. ANON. *Ceram. Ind.*, **24** [1], 25 (1935).—The Ohio Foundry Co., Cleveland, Ohio, is producing washing machine tubs in green, blue, and a bluish-ivory in a single coat. The tubs are first dipped and then reinforced with spraying on the inside and the exterior, except at the bottom. The finished job is produced at a saving of 30% enameling costs compared with the old two-coat enamel method. The single coat is slightly more than half the thickness of two coats. E.J.V.

Phonolite enamel. ANON. *Glashütte*, **64** [26], 438–41 (1934).—After discussing phonolite of various German deposits and its suitability for enamels, experiments with white and colored enamels containing it are described. It was found that Brohltal phonolite is not only a valuable substitute for feldspar in dark colored enamels, but can also be used with success for white enamels. Phonolite considerably improves the chemico-physical properties of enamel. See also *Ceram. Abs.*, **13** [4], 81 (1934). M.V.K.

Porcelain enameling becomes an important division of ceramic engineering courses. A. F. GREAVES-WALKER. *Enamelist*, **12** [3], 13 (1934).—Recognizing the progressiveness of the enameling industry, the ceramic schools are offering courses in enameling as required for graduation. Citing the case at University of North Carolina, 90% of the graduates and post graduates since 1929 have entered the enameling field. E.J.V.

Porcelain enameling of small parts. HORACE R. WHITTIER. *Better Enameling*, **5** [11], 6–7 (1934).—The adaptability of porcelain enamel as a finish for small items such as clock dials, meter dials, insulated screw eyes, oven thermometers, etc., is pointed out. Illustrated. E.J.V.

Reactions important for adherence when firing ground coats containing no adherence-promoting oxides. A. DIETZEL AND K. MEURES. *Jour. Amer. Ceram. Soc.*, **18** [2], 35–37 (1935).

Recent enameling clay development. G. H. MCINTYRE. *Enamelist*, **12** [2], 18–19 (1934).—A study of clays for properties similar to those of Vallendar clay showed that all domestic clays lacked opacifying power, so a study of blends was made. By combining certain clays of high opacifying power with other clays of good suspending power, keeping other desirable characteristics, a combination of clays was developed superior in nearly every respect to any single clay including standard Vallendar clay. Comparative tests showed that the new blend in comparison with standard Vallendar clay has the following characteristics: (1) greater opacity, (2) greater resistance to chipping, (3) equal cross-bend strength in the enamel, (4) no effect on acid resistance, (5) improved dry film strength, (6) better luster and surface texture of the fired enamel, (7) increased bonding range of ground coats, and (8) working characteristics of the liquid enamel remain unchanged. Illustrated. E.J.V.

Review of research on reboiling during the past year. J. O. LORD. *Bull. Amer. Ceram. Soc.*, **14** [1], 14–17 (1935).

Screen process for porcelain enameled parts. ANON. *Better Enameling*, **5** [12], 6–9 (1934).—The screen process for porcelain enamel differs from other screen processes in the use of an extremely fine mesh metal wire screen in place of the usual silk screen. The preparation of the screen for the actual printing operation is a highly specialized photographic process. The main function of the equipment is to produce a negative of the design desired; this negative is used to transfer the design to the screen by exposing it to light. In the case of designs having two or more colors in close proximity, a screen is required for each color. The equipment for the application process in the enameling plant consists chiefly of a printing table and accessories as well as the necessary screens and printing inks. A detailed description of this equipment and its use in the printing process is given. Illustrated. E.J.V.

Sodium nitrite: a dangerous material. M. E. MANSON. *Enamelist*, **12** [3], 12–13 (1934).—Sodium nitrite in small quantities is used in inhibiting rusting of iron or steel covered with wet enamel. This is a deadly poison and must be handled carefully to prevent fatalities. This salt is very unstable, oxidizing readily in air to the nitrate, and

therefore it is recommended that it be purchased in small lots in glass-stoppered bottles, that the bottles be labeled poison, and that the men who handle it be properly instructed as to the danger. E.J.V.

Technique of powder enameling. HUGO SCHULZE. *Glashütte*, **64** [34], 576–78; [35], 588–89; [36], 603–605; [41], 675–79; [45], 733–34 (1934).—The following subjects are discussed: (1) development of the enameling of cast-iron ware by means of the powder method, (2) apparatus used, (3) advantages of using liquid fuel, (4) compositions of powder enamels, (5) composition of cast iron, (6) immersion method, (7) majolica enameling, (8) porcelain-like enameling, (9) cast powder enamel, and (10) various patents dealing with special enameling methods. M.V.K.

Titanium and zirconium compounds: their application in enamels. C. A. DUTTON AND B. F. WAGNER. *Ceram. Ind.*, **24** [1], 24–25 (1935).—While enamels can be made opaque with titanium alone, they are colored because the compounds responsible for the opacity are colored. Titanium oxide increases the fluidity of enamel melts. It is too powerful a flux and dissolves too readily in enamels to form a good mill addition opacifier. Antimony-bearing, vitreous enamel formulation, designed especially for titanium, can contain up to and in excess of 14% TiO_2 and produce stable, white, acid-resisting enamels of great brilliance and good general enameling behavior. E.J.V.

Use of finely milled enamel slips. F. R. PORTER AND H. H. HOLSCHER. *Jour. Amer. Ceram. Soc.*, **18** [2], 39–42 (1935).

Use of pure water in ceramics and enameling. L. F. *Verre & Silicates Ind.*, **5** [20], 384–86 (1934).—Improvement in the quality of the ware and a reduction in the cost of manufacture are frequently obtained by the use of softened, filtered, and deferrized water. M.V.K.

Utilization of unsmelted ground-coat enamels. L. VIELHABER. *Ceram. Ind.*, **23** [6], 314–16 (1934).—A workable ground coat that did not need to be smelted before use was discovered 14 years ago. Advantages include the savings due to elimination of the smelter and its upkeep, elimination of storage of smelted enamel, and saving in milling costs. In drying, a somewhat higher temperature is necessary but after the enamel is properly dried it stands rough handling very well. Sometimes these ground coats fire through at the edges because the separate components are added to the mill in ground form and the mill is not run long enough to further reduce the size of the particles and the mixture may not be entirely homogeneous. Of particular importance is a good distribution of the oxides which promote adherence throughout the batch. Two typical unsmelted enamels which have stood the test of many years of use are given. E.J.V.

BOOK

Defects in Enameling. Their Appearance, Origin, and Means of Elimination (Les défauts dans l'emaillerie. Leur aspect, leur origine, moyens d'élimination). J. NAPPÉE. 44 pp. Price 100 F. Reviewed in *Verre & Silicates Ind.*, **5** [23], 451 (1934).—Various defects appearing when enameling metals are discussed in a practical and systematic manner. A synoptic table showing the defects, their appearance, their origin, and the operations during which they appear is presented. Defects due to enamels, grinding, pickling, application, drying, transportation, furnaces, and firing are differentiated. Illustrated. M.V.K.

Glass

Accuracy of measurement and number of experimental tests in examining properties of glass. K. H. BORCHARD. *Glashütte*, **64** [26], 435–38 (1934).—As a measure of accuracy of measurements, simple formulas for the calculation of "mean error between separate measurements and the mean" are developed and their application is illustrated by examples. M.V.K.

Adhering and adhesive agents in the safety glass industry. FRITZ OHL. *Gelatine, Leim, Klebstoffe*, **1**, 251–55 (1934); abstracted in *Chem. Zentr.*, **ii**, 2876 (1934).—A review is given of materials employed for combining the intermediate layers and glass. See also *Ceram. Abs.*, **13** [2], 36; [6], 145 (1934). M.V.K.

Architectural element in stained glass windows. II. JACQUES WOLF. *Verre & Silicates Ind.*, **5** [21], 404–405 (1934).—The architectural element in stained glass windows appeared as early as the 12th Century and was gradually evolved from a simple enclosure into a decorative frame, perhaps representing the portals of a temple or palace and enriched by decorative borders and inscriptions. An explanation of the rôle of the architectural canopy is advanced. For Part I see *Ceram. Abs.*, **13** [11], 289 (1934). M.V.K.

Batch constituents and their effect on durability of glass. D. B. BURRESS. Presented at 2d Conference on Glass Problems, Nov., 1934, Univ. of Ill., Urbana. Abstracted in *Ceram. Ind.*, **23** [6], 310–13 (1934); *Glass Ind.*, **15** [11], 276 (1934). E.J.V.

Bibliography of alumina and feldspar in transparent glass (1918 to 1933). II. WARING BRADLEY AND DONALD E. SHARP. *Glass Ind.*, **15** [11], 288–90 (1934).—Eighty-six references are given to complete the bibliography. For Part I see *Ceram. Abs.*, **14** [2], 33 (1935). E.J.V.

Calculating self-cost in glass plants. K. H. BORCHARD. *Glashütte*, **64** [42], 687–90; [43], 701–703; [44], 717–20; [48], 789–90; [49], 805–808 (1934). M.V.K.

Checker brick for regenerators. ANON. *Glass Ind.*, **15** [11], 281–82 (1934).—Checker brick must have a P.C.E. value sufficiently high for temperatures encountered, must be resistant to abrasive and fluxing action of flue dusts, and must have a high resistance to spalling, a high thermal conductivity, and a high specific heat. Data are presented for different types of checker brick. E.J.V.

Chilled plate glass. III. Density and hardness of chilled plate glass. IV. Compression, tension, and shock resisting properties. T. ARAKI, S. TAKAHASHI, AND S.

MORI. *Jour. Soc. Chem. Ind.* [Japan], **37** [9], 544–45 (1934); for Part II see *Ceram. Abs.*, **13** [5], 114 (1934). M.V.K.

Coloration given by selenium and cadmium applicable to ceramic decoration. A. GRANGER. *Céramique*, **37** [559], 233–36 (1934).—G. discusses briefly the coloration of selenium and cadmium in glass and suggests their use in glaze formulas. M.H.B.

Combustion of natural gas in the glass furnace. J. E. MCBURNEY. Presented at 2d Conference on Glass Problems, Nov., 1934, Univ. of Ill., Urbana. Abstracted in *Ceram. Ind.*, **23** [6], 322–24 (1934); *Glass Ind.*, **15** [11], 274–75 (1934). E.J.V.

Course in glassmaking. R. D. *Verre & Silicates Ind.*, **5** [17], 324–27; [19], 368–70 (1934).—The Fourcault, Colburn, and Pittsburgh processes of drawing glass, the operation of the machines used, the manufacture of bottles and glassblowing, and the operation of the Boucher machine for making bottles are described. For previous articles see *Ceram. Abs.*, **13** [11], 292 (1934). M.V.K.

Deposition of metals on glass *in vacuo*. H. W. LEE. *Glass Ind.*, **15** [11], 271–72 (1934).—Study of the phenomena accompanying the discharge of electricity through highly rarified gas led to the discovery that the metal cathode (or negative pole) disintegrated when the vacuum was of the order of 0.1 mm. of mercury or 0.0001 atmosphere pressure, and that the finely divided particles, repulsed in all directions from the cathode, would firmly adhere to glass placed near it. This has been developed as a commercial process known as "sputtering." A detailed description of the apparatus and process of depositing metals on glass *in vacuo* is given. Illustrated. E.J.V.

Dilatometric examination of some ternary silicon-sodium-aluminum glasses. E. RENCKER. *Compt. rend.*, **199** [21], 1114–16 (1934).—Expansion coefficient and transformation temperature (which coincides with the beginning of softening) were determined. The results are shown in triangular diagrams. Replacement of Na and Si by Al is always connected with an increase of the softening temperature. It was possible to obtain glasses with a transformation temperature of 800°C which is 150° higher than in the usual most refractive glasses. The expansion coefficient between 20 and 100°C follows Schott's law of additivity only in a very limited region. Replacement of Na by Al reduces the expansion coefficient, replacement of Si by Al reduces it only slightly, and for more than 20% Al the coefficient increases. M.H.

Fuel oil *vs.* producer gas in glassmelting. JOHN KLUMPP, JR. Presented at 2d Conference on Glass Problems, Nov., 1934, Univ. of Ill., Urbana. *Ceram. Ind.*, **24** [1], 28–29 (1935).—In reaching a decision as to the type of fuel that is most economical the following factors must be considered: (1) capital charge on the furnace investment, (2) maintenance cost on furnace equipment, (3) quality of glass as affecting yield, (4) general plant cleanliness, (5) labor, (6) reliability or continuity of service, and (7) direct cost of fuel conditioned and delivered at burners or ports. In comparing costs of producer gas with oil on a two-tank plant pulling 140 T./day, K. estimated that on the basis of all costs chargeable to both types of fuel the cost of using producer gas with coal at $4.50/T. would be $3.18/T. of glass pulled. This compared with $3.00/T. of glass pulled under the same conditions and using oil at 5.681¢/gal. In another plant having five 12-T. tanks pulling 60 T./day, the cost for producer gas with coal at $4.50 worked out to $4.52/T. of glass pulled compared with oil at $4.16/T. of glass pulled, cost of oil 4.3¢/gal. E.J.V.

Glass decoloration. ANON. *Ind. chimique*, **21** [248], 709 (1934).—When introducing cerium in the form of CeO_2 into the glass melt, an equilibrium between CeO_2 and Ce_2O_3 occurs. The increase of temperature promotes the formation of Ce_2O_3 and a liberation of oxygen which produces better refining. The equilibrium between the two oxides depends on the glass composition. Glasses with a lead base are more colored than those free from lead for a given amount of ceric oxide. The decoloration by means of cerium compounds is due to (1) liberation of oxygen, (2) formation of an iron-cerium combination more or less colorless, or (3) simultaneous action of these two reactions. Cerium is also used in glassmelting because of its power to absorb ultra-violet rays. M.V.K.

Glass furnaces of the olden time. H. MAURACH. Presented at summer meeting of Glass Division, Amer. Ceram. Soc., Hammondsport, N. Y., Sept., 1934. *Glass Ind.*, **16** [1], 19–21 (1935).—In discussing ancient glass furnaces M. takes them up in the following general divisions: (1) glassmelting in hearth pits, 3000 to 250 B.C. (to the first use of the blow-pipe); (2) wood-fired pot furnaces, movable to follow the fuel supply, 17th Century A.D.; (3) glass furnaces with grates for wood, later coal, in permanent locations, 1600 to 1850 A.D.; and (4) gas-fired furnaces and tanks, since 1860. Illustrated. See also *Ceram. Abs.*, **14** [2], 34 (1935). E.J.V.

Glass in jewelry. LEOPOLD RIEDEL. *Glashütte*, **64** [38], 627–29; [39], 647–50 (1934).—A general discussion is given of the composition, color, and luster of glass used in jewelry. M.V.K.

Glassmaking in England. ANON. *Verre & Silicates Ind.*, **5** [21], 406–407 (1934).—The contribution of England to the development of the glass industry beginning with the 16th and 17th Centuries is described. M.V.K.

Graphic computation of the strength of window glasses. A. F. DUTTON. *Phil. Mag.*, **17**, 792 (1934).—A formula is cited giving the pressure which a pane of window glass will bear. The formula includes the dimensions of glass and the constants of the material, using a safety factor of 4. The equation is transformed to a second equation which defines a family of curves for different thicknesses and constant pressures which show at a glance the safe dimensions of the glass. A second curve shows the safe working pressures for rectangular sheets of constant thickness. J.T.L.

Heat balance of a glass tank. A. E. BADGER, V. C. FUGMAN, AND H. S. VORMELKER. Presented at 2d Conference on Glass Problems, Nov., 1934, Univ. of Ill., Urbana. *Glass Ind.*, **16** [1], 5–10 (1935).—A heat balance was determined on a glass tank furnace used for the manufacture of electric lamp bulbs. The heat output was summarized as follows: (1) total utilized for glassmelting, 19.1%, (2) total stack loss, 18.3%, (3) radiation losses from surfaces, 30.6%, (4) convection losses from surfaces, 13.3%, (5) cooling water, 2.2%, (6) cooling air, 6.2%, and (7) total unaccounted for losses, 10.3%. E.J.V.

Importance of optics in national defense. GIOACCHINO RUSSO. *Ricerca Scientifica*, **2** [7–8], 43–52 (1934).—The part taken by Italy in the development of theoretical and technical optics and recent progress showing that Italy is no longer dependent on foreign industry are discussed. M.V.K.

Important properties of bottle glass. G. KEPPELER AND F. KÖRNER. *Sprechsaal*, **67** [40], 607–609; [41], 623–27; [42], 640–42 (1934); abstracted in *Verre & Silicates Ind.*, **5** [22], 431 (1934).—The properties of the following bottle glasses were studied: (1) old bottle glass (France), (2) more recent type for mouth blowing (Germany), (3) Owens glass (Germany), (4) American glass (for feeders), and (5) a glass similar to white glass of hollow glassware and yellow glass. The respective mean compositions are as follows:

	I	II	III	IV	V
SiO_2	60.5	63.0	65.4	70.4	73.1
$Al_2O_3 + Fe_2O_3$	7.6	9.7	7.6	2.1	0.8
$CaO + MgO + MnO$	25.8	18.9	14.5	9.8	8.8
$Na_2O + K_2O$	6.1	8.4	12.5	17.6	17.3

When considering these glasses according to their historical development, or in the sequence of the numbers given (I–V), the following conclusions were found: (*a*) Viscosity at which glass may be worked (10^3 poises) is obtained at decreasing temperatures. The range of working for machine glass (III–V) is the same. Because of devitrification of the older type of glass, measurements of viscosity could be taken in a small temperature interval only. (*b*) The danger of devitrification is greater in old glasses (I–III) because of the addition of rocks, while it is insignificant in modern glasses melted from pure materials. The interval between the temperature of working and the temperature of equilibrium (limit of devitrification) increases, while the rate of crystallization and the range of devitrification decrease. (*c*) The coefficient of expansion became larger, from 68.10^{-7} to 84.10^{-7}, and because of this the thermal impact strength was somewhat reduced. (*d*) The transformation temperatures decrease as do the annealing temperatures. The critical zones lie between 85 and 45°C. The ratio between the coefficients of expansion is about 2.8° above and below the transformation point; these ratios are different for glasses III and I, being 3.3 and 3.8, respectively. (*e*) The rate of annealing of glasses IV and V is superior to that of glass III. (*f*) The specific gravities decrease considerably. The measurements calculated according to Gehlhoff do not always agree with those obtained experimentally, while values calculated according to Biltz show good agreement. (*g*) The chemical resistance of old glasses (I, II, III) is high. It is much lower for glasses worked mechanically. A borax glass (72.75 SiO_2, 1.35 Al_2O_3, 0.09 Fe_2O_3, 8.9 CaO, 2.9 B_2O_3, and 13.8 Na_2O) is shorter than glass V, but it can be worked more rapidly. Its rate of crystallization is smaller, its coefficient of expansion is diminished, and its thermal resistance is higher. The annealing time is longer than that of glass V, but the chemical resistance is much higher (46.3 mg. against 19.4 mg.). However, the addition of boric acid increases the cost of the batch. M.V.K.

Kyanite as a source of alumina. S. R. SCHOLES. *Glass Ind.*, **15** [11], 283 (1934).—Kyanite has been suggested as a source of alumina for glass batches on account of its high Al_2O_3 content. It contains approximately three times the alumina content of feldspar. Trial meltings, using 80-mesh raw kyanite, have shown no undissolved material. The quantity used was sufficient to supply 2% Al_2O_3 in the glass. The iron content of kyanite must be low enough to avoid discoloration of the glass but due to the relatively large amount of Al_2O_3 introduced, the tolerable per cent of Fe_2O_3 would be three times as great as with feldspar. The question of cost must also be worked out by the glassmaker. E.J.V.

Manufacture of Triplex glass. FRITZ OHL. *Verre & Silicates Ind.*, **5** [20], 377–79 (1934).—Different materials used for the intercalary layer, the difficulties of manufacture, new types of safety glass, such as the 5-layer glass, organic synthetic glass, and quenched glass are discussed. See also *Ceram. Abs.*, **13** [11], 292 (1934). M.V.K.

Mechanical strength of glass. M. GRENET. *Glass Ind.*, **15** [11], 277–80 (1934); translated from *Bull. soc. encour. ind. nat.*, Ser. 5, Vol. 4, p. 838 (1899).—A report of tests made on two St. Gobain glasses as to cross-bending, effect of rapid rates of loading, and deformation preceding rupture is presented. E.J.V.

Origin and development of spectacles. C. J. S. THOMPSON. *Connoisseur*, **94** [398], 231–39 (1934).—Preceding the use of spectacles, Pliny and Seneca tell that the early Greeks employed a glass ball filled with water for magnifying purposes. The invention of spectacles is generally attributed to D'Armato of Florence. The first lenses were probably of quartz and other semiprecious stones, but when glass was employed the chief center of its manufacture was Venice; later, in the 16th Century, the Germans acquired the art. Improvements in the construction of glasses began in America in the 18th Century when Benjamin Franklin suggested bifocal lenses. Illustrated. E.B.H.

Packing and storing glass panes. G. KILLIAN. *Fachausschussber. Deut. Glastech. Ges.*, No. 28 (Feb., 1934); abstracted in *Chim. & ind.*, **32** [4], 856 (1934).—Pane glass becomes dull only when water is deposited on its surface, especially by condensation of atmospheric moisture. If this water does not dry rapidly it attacks the surface and deposits alkalis which become more concentrated because of evaporation and attack more energetically. This defect occurs more easily in machine-made glass than in mouth-blown glass as the former is not fire polished and the humidity dries less rapidly between glass sheets. This corrosion may be lowered by additions of borax and by increasing the alumina content. This surface corrosion may be decreased also by (1) leaving the glass sheets in water (dissolving of surface alkalis) for a certain time, (2) leaving them in the air unpacked, (3) washing them with an HCl solution, (4) subjecting them to warm smoke, and (5) coating them with glycerine. M.V.K.

Phenomena of dissociation and accelerating the process of glassmelting. L. K. KOVALEV. *Keram. i Steklo*, **10** [10], 32–34 (1934).—To accelerate the rate of melting and to improve glassmelting when working in tank furnaces, it is necessary to dilute the concentration of CO_2 in the gaseous layer present over the batch. This is done by introducing air and gases. The effec of accelerators is to

dilute the amounts of CO_2 liberated. They are compounds melting at low temperatures and liberating gases which are not contained by the basic components of the batch. M.V.K.

Physics of glass. E. Berger. *Z. tech. Physik*, **15** [11], 443–51 (1934).—A review of the physics of glass is presented including the following subjects: relations of glass and crystals, composition of glass and its properties, change of characteristics of a glass by increasing the temperature, theory of the transformation point, influence of thermal pretreatment on the characteristics of a glass, and theoretical considerations. W.M.C.

Practical glass tank operation. James Arrandale. Presented at 2d Conference on Glass Problems, Nov., 1934, Univ. of Ill., Urbana. Abstracted in *Ceram. Ind.*, **23** [6], 300–303 (1934); *Glass Ind.*, **15** [11], 267–70 (1934). E.J.V.

Problems connected with the manufacture of high quality and artistic glassware. I. S. Shur. *Keram. i Steklo*, **10** [9], 14–20 (1934). M.V.K.

Problems and perplexities in the glass industry. Wm. M. Clark. Presented at 2d Conference on Glass Problems, Nov., 1934, Univ. of Ill., Urbana. Abstracted in *Ceram. Ind.*, **23** [6], 324 (1934); *Glass Ind.*, **15** [11], 273 (1934). E.J.V.

Production of glass wool for industry. Chance Brothers & Co., Ltd. *Ind. chimique*, **21** [247], 630 (1934).—Because of improved working methods, glass wool is produced in long flexible fibers which are used in industry as insulating material. This material is entirely inert, but is attacked by hydrofluoric acid. It is stable up to 1000°F, and its elasticity enables it to resist dilatation, contraction, and vibration without harm. M.V.K.

Refining of glass. R. D. *Verre & Silicates Ind.*, **5** [17], 321–22 (1934).—The following refining agents and their use in practice are described: arsenic, antimony oxide, saltpeter, sodium sulfate, carbon and sulfur, sodium chloride, fluorides, and ammoniacal salts. M.V.K.

Relation of natural gas to the glass industry. C. F. Henness. Presented at 2d Conference on Glass Problems, Nov., 1934, Univ. of Ill., Urbana. Abstracted in *Ceram. Ind.*, **23** [6], 322 (1934); *Glass Ind.*, **15** [11], 274 (1934). E.J.V.

Safety glass yields on impact. Edward H. Sykes. *Ceram. Ind.*, **24** [1], 20–23 (1935); for abstract see *Ceram. Abs.*, **13** [1], 8 (1934). E.J.V.

Stones—whence do they come? Anon. *Glass Ind.*, **16** [1], 13–14 (1935).—By use of a petrographic microscope most minerals can be almost definitely identified without chemical assistance. In identifying stones in glass some history of the stones such as the batch composition, furnace temperature, refractories used, and any other available information is of value to the investigator. Most batch stones are found to be silica undergoing solution. These are usually eliminated by more thorough batch mixing, by changes in temperature distribution in the furnace, or a slower draw. The compound $Na_2O{\cdot}3CaO{\cdot}6SiO_2$ is the principal mineral which would crystallize from most common soda-lime glasses. Should the mineral appear as a stone it is likely that, due to poor circulation, variations in glass level, or some such irregularity, glass in some part of the furnace is being heat-treated at temperatures around 2000°F to permit crystallization to take place, and pieces of recrystallized material are breaking from the furnace. Tridymite and cristobalite are sometimes found nicely crystallized but it is difficult to say if they are recrystallized from solution, if they are spalls from the refractory, or if they are batch stones of silica which have inverted from quartz. Nephelite ($Na_2O{\cdot}Al_2O_3{\cdot}2SiO_2$) has been found as a recrystallization product. Refractories frequently cause stones by their extreme insolubility or by their poor bond. Corundum as a stone may come from clay converted to mullite, the mullite breaking down in the presence of alkalis, from cements used as mortars, or from poorly bonded refractory itself. Clay refractories allow sufficient glass penetration to develop a layer of nephelite on their surface and slightly beyond. E.J.V.

Storing of sheet glass. Ernst Luck. *Glashütte*, **64** [33], 543–46 (1934).—Reasons for the dulling of sheet glass during storing and ways for preventing it are discussed in detail. M.V.K.

Temperature of external surfaces of a tank furnace and of a Fourcault drawing channel. V. V. Vitshas. *Keram. i Steklo*, **10** [10], 16–17 (1934). M.V.K.

Temperature-viscosity relations in liquid glasses. A. Tielsch and K. Endell. *Glastech. Ber.*, **12** [3], 84–87 (1934).—A simple sure-working ball viscometer and its calibration are described. Viscosities of 1 to 100,000 poises between 850 and 1450°C can be measured with good reproducibility. The results of viscosity measurements on nine glasses whose viscosities lie between 2.8 and 2100 poises at 1400°C are given in graphic form. The apparatus is useful in following the influence of various metallic oxides on the temperature-viscosity relations of glasses and slags. G.R.S.

Tough glass breaks rules. Anon. *Glass Ind.*, **15** [11], 282 (1934). An exceedingly tough glass for use in industrial goggles, spectacles, etc., is produced by quickly cooling from the softening point, about 1500°F, by an air jet or immersion in oil at approximately 400°F. The exterior layer is quickly solidified while the interior, cooling at a slower rate, contracts and places compressive forces on the exterior. The interior is placed under very strong opposite but equal tensions. Strains are intensified but their direction is controlled to obtain symmetrical stresses. E.J.V.

Ultra-violet transmission changes in glass as a function of the wave-length of the radiation stimulus. W. W. Coblentz and R. Stair. *Jour. Research Nat. Bur. Stand.*, **13** [6], 773–97 (1934); R.P. 744. Price 5¢.—Continuing the research previously reported in Research Paper 113 (*Ceram. Abs.*, **9** [1], 22 (1930)), further consideration is given to methods of testing the photochemical stability of window glass made for transmitting short wave-length ultra-violet solar radiation. It is shown that accelerating the stabilization of the transmission of window glass (equivalent to the stabilization produced by sunlight) by means of filtered ultra-violet radiation from the quartz mercury arc is impracticable principally because of the antagonistic action of radiation of wave-lengths in the region of about 365 mμ which reverses, in varying degrees, the photochemical reaction produced by the shorter wave-lengths. A new phenomenon in the ultra-violet transmission be-

havior of certain glass is reported. Briefly, the phenomenon is as follows: When irradiated with light of a given wave-length (in the region 250 to 365 mμ) the sample of glass reaches an equilibrium state in which the transmission, *e.g.*, at 302μ, attains a certain value which is a constant for the given wave-length stimulus. The equilibrium value of the transmission is different for each wave-length of the radiation stimulus and is independent of the previous order of treatment of the glass. In place of a chemical analysis, the absorption spectrum, which is a characteristic of every chemical compound, is used as a criterion for judging the magnitude of photochemical action produced by ultra-violet radiation of different wave-lengths of homogeneous radiation. In the soda-lime glasses examined (whether or not they combined an appreciable amount of iron oxide) the photochemical equilibrium was found to be different for each wave-length of homogeneous radiation to which the glass reacts. To attain this equilibrium, the reaction caused by a given wave-length is in the direction to either increase or decrease the transmission, depending upon the existing condition developed by previous heat treatment or by previous exposure to other wave-lengths to which the glass reacts. Using homogeneous radiation, no wave-length (at least not for wave-lengths shorter than 365 mμ) was found that has the exclusive property of either increasing or decreasing the ultra-violet transmission in the soda-lime-silica glasses examined. The longest wave-length having an appreciable photochemical action on a soda-lime-silica glass is at about 405 mμ. For wave-lengths 365 mμ and shorter, the photochemical action as determined by the equilibrium levels in spectral absorption is a function of the wave-length (the frequency) of the radiation stimulus; the shorter the wave-length, the greater is the photochemical action in the direction of greater absorption. In contrast with a soda-lime-silica glass, a phosphate-lime glass containing oxides of Al, B, Na, Mg, Si, and Fe as minor constituents is depreciated in ultra-violet transmission only by wave-lengths shorter than about 290 mμ. After depreciation, the ultra-violet spectral transmission curve of the calcium phosphate glass is similar to that of a soda-lime-silica glass. Nevertheless, exposure of the depreciated calcium-phosphate glass to homogeneous radiation of wave-lengths 297 to 365 mμ does not appreciate the transmission, as is the case in the soda-lime-silica glass. In other words, in contrast with the soda-lime-silica glass, certain wave-lengths have the property of decreasing the ultra-violet transmission, but in the spectral range investigated no reverse reaction was observed. R.A.H.

Using Karabugaz sulfate in glassmaking and in fundamental chemistry. N. N. KHOLODILIN. *Keram. i Steklo*, **10** [10], 4–6 (1934).—The advantages of using the metasilicates of sodium and calcium instead of soda when melting glass are discussed, and the process of obtaining the respective metasilicates is described. M.V.K.

Using polymerization products of acrylic acid in the manufacture of safety glass. ANON. *Ind. chimique*, **21** [248], 710 (1934).—Due to their remarkable properties of elasticity, polymerization products of acrylic acid are used in the safety glass industry because these products are "actinic" and resistant to atmospheric agents. They are also resistant to temperatures over 100°, to mineral oils, oxidizing agents, and weak alkalis. M.V.K.

X-ray is answering the question, "What is glass?" GEORGE L. CLARK. Presented at 2d Conference on Glass Problems, Nov., 1934, Univ. of Ill., Urbana. Abstracted in *Ceram. Ind.*, **24** [1], 34–38 (1935). E.J.V.

BOOKS

After-Treatment of Glassware. I. S. SHOOR. Ukrainian State Pub. House of Light Ind., Kharkov, 1933. 176 pp., 106 illustrations. Price 3 R. The book has 15 chapters which are as follows: (1) different kinds of after-treatment of glass, (2) cutting of flat glass, (3) cutting of hollow glassware, (4) after-treatment of glass by grinding and polishing, (5) construction and operation of grinding and polishing apparatus, (6) defects in polished glass, (7) grinding of hollow ware, (8) faceting (beveling) of plate glass, (9) decorative grinding of glassware, (10) remelting, (11) sandblasting, (12) drilling holes in glass, (13) acid etching of glass, (14) painting on glass, (15) metal deposition on glass. S.I.PERKAL

Furnace Crowns (Voutes de Foyers). K. HARRABUS. Translated into French by de Rova-Berni. Charles Beranger, Liége, Paris. Price 45 F. Reviewed in *Verre & Silicates Ind.*, **5** [27], 451 (1934); for abstract see *Ceram. Abs.*, **13** [1], 15 (1934). M.V.K.

Manual for Self-Instruction in Glass Blowing (Lamp Working). A. E. ARBUZOV. 2d ed., revised and enlarged. State Chem.-Tech. Pub. House., Moscow and Leningrad, 1933. 144 pp. Price 2 R. The first book published in 1912 was a brochure of 60 pp. A., professor of Butlerov's Chemico-Technological Institute of Kazan, has designed much glass apparatus. The first 16 pp. give data on materials necessary for lamp working, storing and cleaning of tubes, glass-blower's instruments, etc. The second section is a detailed and sufficiently well-illustrated description of numerous kinds of separate operations used in lamp working (cutting of tubes and rods, making of bends and junctions, soldering, grinding, boring of holes, calibration, etching, silvering, etc.). The last section (pp. 68 to 144) is devoted to the making of chemical and physicochemical apparatus. S.I.PERKAL

Quartz Glass: Its History, Manufacture, and Uses (Quarzglas: Seine Geschichte, Fabrikation und Verwendung). PAUL GÜNTHER. Julius Springer, Berlin, 1911. 52 pp. This small, easily readable brochure deals with the history of quartz glass (Gaudin 1839, Gautier 1869, C. V. Boys 1889, Keraeus 1899, etc.), its manufacture from mountain crystal and from quartz sand, electrical furnaces for melting (Bolle, Vogel, Mehner, Völker), treatment of the glass mass, physical and chemical properties, and uses. The prices for quartz glass pipes are given and a bibliography is appended. S.I.PERKAL

PATENTS

Adjustable lip for glassmelting tanks. J. H. FOX (Pittsburgh Plate Glass Co.). U. S. 1,984,923, Dec. 18, 1934.

Apparatus for:

Fabricating glassware. A. J. SMITH (Hartford-Empire Co.). U. S. 1,986,765, Jan. 1, 1935.

Feeding molten glass. E. C. STEWART. U. S. 1,986,650, Jan. 1, 1935.

Apparatus for (*continued*)

Handling and inspecting plate glass. H. S. HEICHERT (Pittsburgh Plate Glass Co.). U. S. 1,983,755, Dec. 11, 1934.

Making insulating glass. J. H. Fox (Pittsburgh Plate Glass Co.). U. S. 1,984,924, Dec. 18, 1934. WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 1,984,942, Dec. 18, 1934.

Apparatus and method for delivering molten glass. W. T. HONISS (Hartford-Empire Co.). U. S. 1,986,575, Jan. 1, 1935.

Apparatus and method for fabricating glassware. A. J. SMITH (Hartford-Empire Co.). U. S. 1,986,766, Jan. 1, 1935.

Centering device for lens machinery. T. B. DRESCHER (Bausch & Lomb Optical Co.). U. S. 1,984,121, Dec. 11, 1934.

Cups, bowls, glasses, jugs, etc., tableware. DUDSON BROS., LTD., AND H. S. DUDSON. Brit. 420,842, Dec. 19, 1934.

Device for feeding glassmaking materials to melting tanks or furnaces. HARTFORD-EMPIRE CO. Brit. 419,681, Nov. 28, 1934.

Double lens structure. W. M. THOMAS. U. S. 1,984,953, Dec. 18, 1934.

Electric incandescent lamps. L. F. DE BACKER. Brit. 420,841, Dec. 19, 1934.

Fused preparation for glass batches. F. C. FLINT (Hazel-Atlas Glass Co.). U. S. 1,986,720, Jan. 1, 1935. A preparation for a glass batch comprises the product resulting from a fusion of a mass consisting of barium sulfate and a metal halide.

Glass blank transfer. C. C. KINKER (Hartford-Empire Co.). U. S. 1,985,416, Dec. 25, 1934.

Glass bottles. A. G. ENOCK, AUTO-DAIRY PIONEERS, LTD., AND UNITED GLASS BOTTLE MFRS., LTD. Brit. 420,839, Dec. 19, 1934.

Glass cutting apparatus. WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 1,984,943, Dec. 18, 1934.

Glass polishing tools. PILKINGTON BROS., LTD., AND F. B. WALDRON. Brit. 419,747, Nov. 28, 1934.

Heat-retaining float for glass tank feeding shelves. F. G. SCHWALBE. U. S. 1,983,816, Dec. 11, 1934.

Laminated glass. RÖHM & HAAS CO. Brit. 420,159, Dec. 12, 1934.

Lens grinding machine. J. J. MCCABE (Bausch & Lomb Optical Co.). U. S. 1,984,074, Dec. 11, 1934.

Lens testing instrument. L. V. FOSTER (Bausch & Lomb Optical Co.). U. S. 1,984,123, Dec. 11, 1934.

Manufacture of laminated glass. TRIPLEX SAFETY GLASS CO., LTD., L. V. D. SCORAH, AND J. WILSON. Brit. 420,073, Dec. 5, 1934.

Method and apparatus for feeding glass blanks to pressing machines. H. R. SCHUTZ (Libbey Glass Mfg. Co.). U. S. 1,986,449, Jan. 1, 1935.

Method and apparatus for manufacturing single layer wired glass. SCHLESISCHE SPIEGELGLAS-MANUFACTUR C. TIELSCH GES. Brit. 420,583, Dec. 19, 1934.

Method and apparatus for use in cutting laminated glass. C. B. SCHAFER (Libbey-Owens-Ford Glass Co.). U. S. 1,985,520, Dec. 25, 1934.

Method of manufacturing composite sheets of glass by rolling. SCHLESISCHE SPIEGELGLAS-MANUFACTUR C. TIELSCH GES. Brit. 420,611, Dec. 19, 1934.

Ornamental glass and method of making. G. L. WEST (Pittsburgh Plate Glass Co.). U. S. 1,983,720, Dec. 11, 1934.

Receiving table for glass sheets. WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 1,983,769, Dec. 11, 1934.

Recuperative glassmelting tanks. P. L. GEER. Brit. 420,541, Dec. 19, 1934.

Splinterless material particularly splinterless glass. KARL DAIMLER AND GERHARD BALLE (I. G. Farbenindustrie A.-G.). U. S. 1,984,671, Dec. 18, 1934.

Surface-decorated glass and its production. PILKINGTON BROS., LTD. (Vitrolite Co.). Brit. 420,837, Dec. 19, 1934.

Tank construction. W. G. KOUPAL (Pittsburgh Plate Glass Co.). U. S. 1,984,932, Dec. 18, 1934.

Transparent heat-resisting borosilicate glass. R. HADDAN (Corning Glass Works). Brit. 420,054, Dec. 5, 1934.

Vitreous material and process of making. P. K. DEVERS (General Electric Co.). U. S. 1,984,178, Dec. 11, 1934. An insulating composition having essentially the properties of fused silica but being characterized by improved workability when plastic and decreased brittleness consists mainly of silica and contains as constituents about $\frac{1}{7}$ to $1\frac{1}{2}\%$ of beryllium oxide and about $\frac{1}{8}$ to 2% of aluminum oxide.

Work-holders for lens blanks. O. G. HAUSSMANN. Brit. 419,490, Nov. 28, 1934.

Structural Clay Products

De-airing clay in the auger machine. JOSEF REMENYI. *Slavivo*, p. 51 (1934).—Tile were weighed immediately after pressing. The tile pressed under a vacuum of 91% was 8% heavier than the same tile when not de-aired. After firing, the difference in weight was 4 to 4.5%. By de-airing, the drying time is shortened while power consumption rises only 5 to 6%. A vacuum of 95% corresponds to 68 to 69 cm. of mercury column. De-aired bodies have better elasticity and plasticity and are free from voids. Illustrated. R.B.(*R.C.C.S.*)

Essential properties of mortars for masonry units. L. A. PALMER. *Brick Clay Rec.*, 85 [5], 161–68 (1934).—Adaptability is the effect of a combination of necessary mortar properties which, listed in order of their importance, are (1) workability, water-retaining capacity being the controlling factor, (2) adhesiveness or bonding power, a high ratio of tensile bond strength to tensile mortar strength, (3) low volume changes subsequent to hardening, (4) maximum amount of strength obtainable without any material sacrifice of plasticity, bonding power, and low volume change after hardening, (5) extensibility, the property of undergoing a relatively high degree of

stretching without rupture, (6) freedom from soluble matter that contributes to efflorescence, staining, etc., and (7) a fair degree of porosity. E.J.V.

Experiences with re-pressed hollow tile. A. Bušina. *Stavivo*, p. 164 (1934).—A 30-cm. wall built of Jestav hollow tile which is closed on five sides has the same insulating value as a 45-cm. wall of common brick. In using the Jestav brick, 22% mortar and 35% labor were saved. Illustrated. R.B.(*R.C.C.S.*)

How brickmakers judge "Jestav" brick. Fr. Svoboda. *Stavivo*, p. 431 (1933).—The closed hollow brick, Jestav, has proved a success. Kiln capacity is raised 20% and fire progress 7 to 15%. Fuel consumption is reduced 25 to 30%. Nine hundred sixty brick are pressed hourly. Illustrated. R.B.(*R.C.C.S.*)

Insulating value of hollow brick. W. Dawihl. Translated by W. D. Richardson. *Brick Clay Rec.*, **85** [6], 197–98 (1934).—The three ways by which heat can pass through a hollow brick (convection, conduction, and radiation) are discussed, and D. points out how the alteration of the size and shape of the openings in the brick changes the amount of heat transmitted. Practical tests of hollow brick showed that a brick with many small holes, in spite of the lower water absorption of its body, had a lower heat conductivity than a similar brick with larger holes. As fine-pored brick have the least heat conductivity they have the best insulating values. Illustrated. E.J.V.

Investigations on clinker brick and clinker masonry. Fr. Klokner. *Stavivo*, p. 334 (1933).—Strength may be judged best from the crushing strength and transverse strength of the whole brick. Results show small deviations and correspond to the strains to which the brick is subjected in the wall. The strength of walls is best determined on cubes with edges 30 cm. in length. The strongest wall was not that of the best clinker brick, but that of a brick with medium strength. With this clinker brick the wall had 48% of the strength of the brick, while with two other clinker brick only 37 and 40% were reached. The strength of the walls examined was 71 to 94% higher than that of the mortars used. The modulus of elasticity for walls constructed of clinker brick and cement mortar was about 96,000 kg./cm.^{2}. The proportion between strength of brick and strength of masonry is about 0.25 to 0.3 and averages 0.3 for common brick; for clinker brick it is 0.39 to 0.54 with an average value of 0.48. Clinker brick, with higher strength, is therefore not as satisfactory in the wall as common brick. Illustrated. R.B.(*R.C.C.S.*)

Isokeramit. Jan Putterlík. *Stavivo*, p. 352 (1933).—This is a hollow brick closed on all sides with the standard dimensions of 29 x 14 x 6.5 cm. Its walls have a thickness of 20 mm. and the weight of the brick is 2 kg. Illustrated. R.B.(*R.C.C.S.*)

"Jestav" brick. Karel Jezek. *Stavivo*, p. 50 (1934).—The advantages of these closed, hollow, double brick of Czechoslovakian make, which are produced by a Jestav press (*Ceram. Abs.*, **13** [5], 119 (1934)), are as follows: The brick may be picked up with one hand; it binds with any other brick of standard dimensions; it may be divided into two parts without chippings by chopping; and it may be used as facing tile. It has a high insulating value and saves mortar and 45% in weight. The auger-made brick are cut automatically by a cutting apparatus and passed to the revolving press. The upper part of the pressing mold is formed by two pistons of different size which press two holes into the clay. While the press turns, both side walls of the mold are automatically removed and its bottom is raised so that the pressed brick may be taken off. The brick dry faster and, in setting, 20% of kiln room may be saved compared with common brick. The power consumption of the revolving press is 5 h.p. At present 20 brickworks, including Bàta, produce Jestav brick. R.B. (*R.C.C.S.*)

Jointing stoneware pipes. Anon. *Clay Prod. Jour. Australia*, **1** [10], 26 (1934).—The Engineering and Water Supply Dept. of Adelaide has developed a jointing material for sewer pipe which has been very successful. The composition of the material by weight is as follows: 64 medium coarse and fine sand, 6 Undettaker's pitch, 8 distilled tar, 17 Trinidad Lake asphalt, and 5% cement. The quantity of distilled tar can be varied according to atmospheric conditions. S.I.P.

Load tests on structures of reinforced brick masonry. W. R. McCaffrey. *Can. Engr.*, **67** [26], 3–6 (1934).—A series of load tests on structures of reinforced brick masonry carried out at the Ontario Brick and Tile plant, Mimico, Ontario, proved conclusively that brick, mortar, and reinforcing steel, when built together in proper design, form a monolithic structure capable of resisting compressive and tensile stresses when subjected to loads far in excess of those for which the structure is designed. Details of structure design and loading during these tests are given. Illustrated. E.J.V.

Los Angeles chooses sewer pipe on quality standard. Gerald B. Burtnett. *Brick Clay Rec.*, **85** [5], 159–60 (1934).—Excerpts of letters from engineers throughout the country showing the value of clay sewer pipe are given. Pipe for sanitary sewers will be selected on a quality basis from now on. See also "Concrete sewer-pipe failures," *Ceram. Abs.*, **14** [2], 39 (1935). E.J.V.

Manufacturing blast-furnace slag and its characteristics. A. Guttmann. *Stahl & Eisen*, **54** [36], 921–28 (1934).—Methods of manufacturing porous slag are outlined and characteristic data are presented. Slag may be used as a building material where a light weight tile of good heat insulation is required. W.M.C.

Market for clay products. Anon. *Brick Clay Rec.*, **85** [6], 188 (1934).—Tests made at the Ames, Iowa, sewage disposal plant indicate that clay tile of the Raschig ring type are superior to filter bed materials now in use. Illustrated. E.J.V.

"Mileposts" in brickmaking. Alfred B. Searle. *Brit. Clayworker*, **43** [511], 226–29 (1934).—A brief review of some of the more important mileposts in the history of brick manufacture and the directions in which further advantages and improvements may be sought are given. R.A.H.

Obtaining dark colored brick with oxidized firing. K. Zimmermann. *Klei*, **26** [4], 34–36; [5], 40–42 (1934); abstracted in *Chim. & ind.*, **32** [4], 861 (1934); *Tonind.-Ztg.*, **58** [95], 1166 (1934).—A sufficiently dark coloring (although dull) is obtained when adding 2 to 3% manganese dioxide or a 10% mixture of clay and pyrolusite. When a clay containing iron oxide is fired to 1160 or 1200°

ferric oxide may produce FeO or Fe_2O_3 at high temperatures; the latter oxides yield a darker coloring. Iron mineral, especially hematite, ferrous residues from the bauxite treatment, or other industrial residues can be used when ground fine (900-mesh); in this case, up to 10% may be added to the mix. The proportion of iron oxide to CaO should be 1 in the clays used, especially in those rich in iron. This proportion may be adjusted by mixing various clays or by additions of carbonate of lime. Brick of a dark blue or violet color are produced when fired to an appropriate temperature. Surface coloring is obtained (*a*) by introducing pyrolusite to the molding sand and (*b*) by introducing into the furnace certain mixtures of salts when the maximum temperature is reached. The effects obtained depend on the way in which the brick are charged into the furnace. M.V.K.

Perforated brick. Jos. REMENYI. *Stavivo*, p. 214 (1934).—The coefficients of thermal conductivity are 0.34 for hollow brick with holes of 30 x 40 mm., 0.29 for perforated brick with holes of 10 x 10 mm., and 0.24 for porous lightweight brick. R.B.(*R.C.C.S.*)

Producing "Penta" perforated brick. V. RAUBITSCHEK. *Stavivo*, p. 360 (1933).—A new product of Swiss Avan, Ltd., is described. The auger-made brick is perforated on a press from one end so that the opposite end remains closed. The weight is reduced 35 to 40% and corresponding quantities of raw material are saved. R.B.(*R.C.C.S.*)

Sand-lime brick. ANON. *Metallurgia*, **10** [58], 116 (1934).—A brief discussion is given of principles of the production of sandlime brick. The composition of mixture is 85 sand, 8 slaked lime, and 7% moisture. M.V.K.

Silico-calcareous brick. E. V. *Rev. mat. constr. trav. pub.*, No. 301, pp. 292–96 (1934).—The properties, manufacture, and application of silico-calcareous brick are given. M.V.K.

Test methods in ceramics, particularly in the brick industry. JOSEF MATĚJKA. *Stavivo*, p. 161 (1934).—X-ray studies, microscopy, hydrogen-ion concentration, transverse strength, drying in vacuum, permeability, and thermal and sound insulation are discussed. R.B.(*R.C.C.S.*)

Tests on walls of lightweight brick. FRANTIŠEK KLOKNER. *Stavivo*, p. 239 (1933).—Different lightweight (porous) brick of Czechoslovakian producers were examined. The average results were bulk weight 1.007 kg./cm.^{3}, water absorption 59.1%, crushing strength of cubes of 5 cm. edge 20.1 kg./cm.^{2}, crushing strength of two halved brick bonded together 22.5 kg./cm.^{2}, and transverse strength 8.34 kg./cm.^{2}. The ratio between crushing strength of wall and strength of brick was determined on cubical walls of 60 cm. edge. If lime mortar was used, the average ratio was 0.33; with cement mortar it was 0.57. R.B.(*R.C.C.S.*)

Union for the Development of the Brick Industry in Czechoslovakia visits Repov. ANON. *Stavivo*, p. 150 (1934).—A hollow tile called "Isoterit," which is made at Repov, has the dimensions 29 x 14 x 14 cm. and is closed on all sides. R.B.(*R.C.C.S.*)

PATENTS

Building block. H. J. KAUFMAN. U. S. 1,986,759, Jan. 1, 1935. The building block has cutaway portions on the rear side.

Hollow tile. K. JEZEK. Czechoslo. P 4275–32, June 30, 1932; *Stavivo*, p. 129 (1934).—The core area is divided by a rib into two halves of different width. Shallow notches facilitate the chipping of the tile into two parts. R.B.(*R.C.C.S.*)

Hollow tile. M. LEITERSDORF. Czechoslo. P 7690–31, Oct. 19, 1931; *Stavivo*, p. 9 (1934).—A brick of trapezium shape is described. R.B.(*R.C.C.S.*)

Hollow tile block. F. A. HOLBY (N. J. Clay Products, Inc.). U. S. 1,984,972, Dec. 18, 1934.

Hollow tile with one groove as structural material. SLOVENSKÉ AKCIOVÉ CIHELNY. Czechoslo. P 512–30, 1930. R.B.(*R.C.C.S.*)

Interlocking building brick. PHILLIP BROWN. U. S. 1,984,393, Dec. 18, 1934.

Process of manufacturing light nailable brick. HERMANN MAYR. U. S. 1,985,737, Dec. 25, 1934. Nailable brick are produced by firing a composition of loam, turf, collodion, and water.

Refractories

Behavior of fireclay brick against slag attack. FROMM. *Ber. deut. keram. Ges.*, **15** [2], 49–65 (1934).—An investigation was made of fifty refractory brick made by fifteen manufacturers, with respect to their resistance to slag attack. Claims relative to stability to temperature changes are of little importance. The normally used test of 2 hr. exposure to slag attack at 1400° resulted in no sufficient differentiation between the types of brick. Only by increasing the temperature and the duration of the test were sufficient differences observable. No relation between alumina content and behavior toward slag attack could be found. The solubility in slag increases slightly with increasing porosity at 1400°, but at 1450° a greater connection exists between the solubility in slag and the porosity. Only one type of refractory is an exception, this being due to the type and distribution of pore space in it. It is shown how the best suited refractory for use with any given fuel can be determined. E.J.V.

Effect of moisture upon electrical resistance of embedding cements. R. L. MELTON, K. W. BROWNELL, AND G. J. EASTER. *Jour. Amer. Ceram. Soc.*, **18** [2], 70–77 (1935).

Experimental examination of the empirical formula of Shuen, the Ludwig diagram, and the Tchishevsky curve. N. M. SOKOLOV AND G. K. SERGEJEV. *Ogneuporui*, **2** [9], 38–42 (1934).—The above-named methods of calculating refractoriness based on the chemical composition of clays were verified on 24 kinds of clays and brick. The results obtained experimentally (refractoriness and melting point) compared with those calculated theoretically are

shown in tables. The Shuen formula is applicable only for fire clays with a melting point over 1600°C or P.C.E. 26, the Ludwig diagram for over 1630° or P.C.E. 28 and the Tchishevsky curve for 1500 to 1760°. Different materials tested gave varying divergences from the theory. The methods proved to be easily applicable and are recommended for calculating the refractoriness of grog brick. Results obtained according to Ludwig show greater deviations, especially in samples of brick and clay with a high content of Fe_2O_3, TiO_2, or SiO_2. The best results were obtained by the Shuen method, which is especially recommended. P.P.B.

Fluxing and corroding action of lime with regard to clay and refractory products. V. Bodin. *Céramique*, **37** [555], 131–38 (1934).—The effect of lime on various clays and magnesite is discussed. M.H.B.

Gas permeability, resistance to pressure, thermal conductivity, thermal expansion, heat capacity, and inclination to breaking of refractory brick in dependence on porosity. Heinrich Herbst. *Feuerungstechnik*, **22** [10], 115–16 (1934).—The effect of porosity on gas permeability, resistance to pressure, thermal conductivity, thermal expansion (up to 1000°), heat capacity, and inclination to breaking at sudden changes of temperature of a brick containing alumina and having a refractoriness about 1600° is shown in curves. Brick used for the production of gas and coke must be as gas tight as possible. The smallest gas permeability is obtained when porosity is equal to 0 and slowly increases up to 20% porosity. Between 20 and 35% porosity, it increases more rapidly. The greatest thermal conductivity occurs when porosity is 0; it decreases slowly up to 20% porosity. Brick for fire drafts for coke ovens or melting furnaces must have a porosity lower than 20%, while insulating brick must have a 35 to 55% porosity. Brick with 0 porosity have the highest resistance to pressure, the greatest thermal expansion, and the greatest inclination to breaking. M.V.K.

Hardness of talc on firing. V. H. Grigorovich. *Mineral. Suir'e*, **9** [5], 50–57 (1934).—The use of talc as a refractory material depends on its refractoriness, increased hardness, and mechanical strength at high temperatures. The changes in the hardness of talc depending on the temperature of its calcining were studied. The analysis of curves shows the character of the changes brought about by firing to various temperatures. Practical results show that the firing of talc brick should be performed between 1200 and 1300°. Talc refractories can be used with best results at temperatures up to 1300°. M.V.K.

High-temperature insulation for industrial furnaces. I. N. Allen Humphrey. *Blast Fur. Steel Plant*, **22** [12], 703–704 (1934).—Insulation is for the purpose of saving heat or holding it within the heated equipment. Insulating materials are classified by their thermal conductivity and their temperature limits. Thermal conductivities may be determined for mean temperatures between hot and cold surfaces on the basis of hot surface temperatures or on the basis of temperature differences between the hot surface and surrounding air. Formulas for the calculation of thermal conductivities are given. E.J.V.

Hydraulic refractory cements. R. Dubrisay and H. Lafuma. *Céramique*, **37** [557], 185–90 (1934).—Refractory hydraulic cements are composed chiefly of anhydrous monocalcium aluminates called zeolites. They retain their bonding properties at high temperatures because the aluminate is not a definite hydrous salt but a solid solution. With pure materials they are not fused below 1400°C. M.H.B.

Modification of quartz in Dinas brick and their quantitative determination. G. V. Kukolev, N. M. Lozinskiĭ, and E. I. Ter-Mikaelyanz. *Ukrain. Nauchno-Issled. Inst. Ogneuporov i Kislotouporov*, No. 24, pp. 4–51 (1934).—It is possible to determine quantitatively quartz modifications in Dinas brick by means of a Chevenard differential dilatometer with a self-recording apparatus. The limit of error does not exceed 2%. The method of sample preparation has a considerable influence on the results. The method of computing by means of mean coefficients of expansion is unsuitable. For determining quartz in Dinas, rods are cut and ground from a Dinas brick; for determining other modifications, molded samples may be used. They are powdered and molded with 5% soluble silicate and the samples are fired to 800°. Corrections for the added soluble silicate should be made in the calculations. The method of computing by means of average effect of expansion is the usual one. If the curve obtained gives conversion points with sufficient accuracy, calculations can be made using absolute values of the effect of expansion. M.V.K.

Petrographic, fusion, and slag studies of magnesite refractories in rotary kiln service. R. P. Heuer *Rock Prod.*, **37** [12], 42–46 (1934).—A series of petrographic, fusion, and slag studies indicate that the use of unfired magnesite brick in rotary kilns burning Portland cement, dolomite, and similar basic materials under severe service is preferable to that of 70% alumina brick. The magnesite refractory is not subject to the bad fluxing attack which lime- and magnesia-bearing charges exert on 70% alumina brick. The unfired magnesite brick show fusion temperatures in the presence of Portland cement and dolomite clinker approximately 900°F higher than the 70% alumina brick. This higher refractoriness enables the unfired magnesite linings to hold a coating better, permits higher operating temperatures, and gives longer refractory life and lower refractory costs under the most severe operating conditions. Illustrated. E.J.V.

Plastic insulating refractory. J. R. Parsons. *Brick Clay Rec.*, **85** [6], 203–204 (1934); *Blast Fur. Steel Plant*, **22** [5], 294 (1934).—Pire, a plastic insulating refractory used on the hot furnace wall face, starts to vitrify at 1800°F and will stand 2700°F though it is not recommended for continuous service above 2550°F. It has excellent spalling resistance due to coarse grain structure. In plastic form it weighs 82 lb./cu.ft., but after heating it weighs from 55 to 65 lb./cu.ft., depending on how heavily it is rammed into place. E.J.V.

Problems in the utilization of Pennsylvania fire clays. F. A. Harvey. *Bull. Amer. Ceram. Soc.*, **14** [1], 1–7 (1935).

Producing artificial minerals and ware from them in Europe. N. M. Fedorovskiĭ. *Mineral. Suir'e*, **9** [6], 23–28 (1934).—The production of artificial graphite, silicon carbide, and Alundum, and the properties of electrographite are described. M.V.K.

Producing magnesite brick and new kinds of brick from

carbonate raw materials. Z. TABAKOV AND V. BELOVODSKY. *Ogneuporui*, **2** [9], 8–13 (1934).—Processes and production control of a magnesite plant are described. Experiments on obtaining magnesite-dolomite brick with the addition of dolomite waste from a concentration of magnesite ore gave the following results: good spalling resistance, mechanical strength 595 kg./cm.², volume weight 2.70, specific weight 3.72, apparent porosity 18.90%, water absorption 7.0%, load test (beginning of deformation) 1500°. P.P.B.

Producing sagger mixes by modern technique. I. D. FINKELSHTEIN. *Keram. i Steklo*, **10** [11], 9–12 (1934).—Methods used in the working of sagger mixes are described in detail. M.V.K.

Quartz grog mixes. G. V. KUKOLEV AND G. I. SLADOVSKIĬ. *Ukrain. Nauchno-Issled. Inst. Ogneuporov i Kislotouporov*, No. 25, pp. 3–95 (1934).—Silica-grog (semi-acid) products have considerable advantages; they withstand specific working conditions, and have higher quality than pure grog products. Plastic fire clay, silica materials, and grog should be used as raw materials for high-grade refractories for severe working conditions (coke-ovens, steel ladles, cupolas, etc.). The fire clay should be of high plasticity and bonding power and have a low sintering temperature. Kaolin should not be used for high-grade refractories. Crystalline quartz or crystalline quartzites with a minimum content in amorphous particles are used as silica materials. Fired refractory clay and crushed grog products, if they do not contain slag or other impurities, are used for grog. The amount of quartz material used should not be less than 40% so that the silica content of the fired body will not be less than 75%; the amount of grog should not be less than 20%. The firing is done at cone 14. For service at comparatively low temperatures, but in regions where refractories are subjected to abrasion, finely ground soft cement quartzite may be added to the mix to increase the mechanical strength. M.V.K.

Refractories industry is reaching goal of better products. E. B. GUENTHER. *Brick Clay Rec.*, **85** [6], 206 (1934).—Super-fireclay brick having high refractoriness, high temperature of incipient vitrification, and low spalling tendency are being made from very refractory clays or kaolins specially selected, either with or without additions of small amounts of higher alumina content minerals. High-alumina brick are now available having 50, 60, 70, and 80% alumina. Insulating brick of diatomaceous earth and lightweight brick are further developed. Power-press production of silica brick and vacuum pressing or de-airing have resulted in denser brick having higher heat capacity and greater resistance to penetration by gases and slags. E.J.V.

Refractory cement with chrome base. ANON. *Ind. chimique*, **21** [248], 711 (1934).—This product called "Adachrome" is very plastic; it does not shrink, produces a smooth surface, and can be applied on refractory insulating brick which easily absorb moisture. It can be kept indefinitely in a suspended state and it hardens rapidly in air without the addition of silicate. M.V.K.

Refractory materials for blast furnaces. III. A. B. SEARLE. *Blast Fur. Steel Plant*, **22** [11], 660–61 (1934).—The strength that is important in the top zone is more nearly related to hardness. If a crushing test is used it should be made at a temperature near that at which the brick will be used. For the top zone the best brick are fireclay brick, sufficiently dense and fine in texture to be highly resistant to wear and corrosion, with a low refractoriness. In the second zone the abrasive action of the charge is very great, as is the chemical action of the gases and fluxes, and a higher refractoriness is needed but the brick must be dense and firm in texture. Fireclay brick containing 26 to 30% alumina are usually of ample refractoriness and if thoroughly well fired are hard enough and dense enough to resist abrasion and corrosion of the charge. The hearth and bosh or well are the hottest parts of a blast furnace and the brick must be sufficiently hard and dense to prevent undue penetration by slag and melt and still be very refractory. Brick containing 40% or more alumina are being used. For Part II see *Ceram. Abs.*, **14** [2], 40 (1935). E.J.V.

Reliability of measurements of the thermal conductivity of refractory brick. J. B. AUSTIN AND R. H. H. PIERCE, JR. *Jour. Amer. Ceram. Soc.*, **18** [2], 48–54 (1935).

Sagger bodies. G. A. LOOMIS. *Bull. Amer. Ceram. Soc.*, **14** [1], 8–12 (1935).

Shapes and uses of grog brick. O. W. *Feuerungstechnik*, **22** [10], 120–21 (1934).—A general discussion is given of the importance of the correct shape of grog brick. M.V.K.

Slag test in the open-hearth process. R. BACK. *Stahl & Eisen*, **54** [37], 945–54 (1934).—Physical characteristics of slag samples and chemical composition have been correlated. Outside appearance and surface of fracture are characteristic for the presence of certain compounds in a slag. The physical characteristics of a slag will change with an increasing basicity giving valuable help in melting steel in the open-hearth process. The ratio $V = \frac{CaO}{SiO_2}$ should be determined. This will give conclusions regarding the workability of the slag. W.M.C.

Small cast thorium oxide crucibles. H. K. RICHARDSON. *Jour. Amer. Ceram. Soc.*, **18** [2], 65–69 (1935).

Spalling of refractories. ANON. *World Power*, **21** [125], 261–62 (1934).—Physical spalling may be caused either by a very steep temperature gradient through the refractory, as occurs particularly when water cooling is installed, or by rapid temperature changes. The effect in either case is to modify the physical properties of the material irregularly so as to cause cracking. Mechanical spalling results from localized stresses due to expansion of the mass and is liable to occur in arches through the reversible thermal expansions causing the arch to rise and alter its curvature. This subjects the inner ends of the brick to local compression and is accentuated in arches of low curvature. E.J.V.

Talc and dunite sagger mixes. R. T. MAKHL. *Keram. i Steklo*, **10** [10], 29–32 (1934).—Results of experiments with sagger mixes containing talc and dunite are discussed. When comparing data with talc and dunite mixes, it is seen that talc mixes are superior in every respect to those containing dunite. Sagger mixes containing 15% dunite or talc were found to be the best; they have a high strength and are sufficiently refractory. Data are given in tables and diagrams. M.V.K.

Testing corundum from the Chainuitskiĭ deposits. S. G.

GLAZUNOV. *Mineral. Suir'e*, 9 [4], 25–27 (1934).—The natural Yakutskiĭ corundum (Siberia) is not of lower quality than ordinary electrocorundum with regard to its chemico-technological properties. This corundum is an ore of high purity containing 88.5 to 94% alumina. M.V.K.

Testing refractory industrial materials. J. L. B. *Klei*, No. 18, p. 148 (1934); abstracted in *Tonind.-Ztg.*, 58 [81], 996 (1934).—Suggestions for standardizing methods of investigations of refractory materials and a summary of methods used abroad are given. M.V.K.

Thermal conductivity of refractories under operating conditions. R. H. HEILMAN AND R. S. BRADLEY. *Jour. Amer. Ceram. Soc.*, 18 [2], 43–48 (1935).

Tkvibul-slate (Caucasus) as raw material for the alumina industry. I. YA. KLINOV AND D. YA. SUICHEV. *Legkie Metallui*, 2 [10], 26–38 (1934); abstracted in *Chem. Zentr.*, ii, 3158 (1934).—A method is described for obtaining 99.9% alumina (0.1% Fe_2O_3) from ash of the slate fired to 700° when treating it with hydrochloric acid. M.V.K.

Utilization of Satka magnesite. M. ORTIN. *Ogneuporui*, 2 [9], 3–7 (1934).—The magnesite deposits at Satka, Ural, can be considered the greatest in the world. The average composition of the ore is 45.5 MgO, 1 to 1.25 CaO, 1 SiO_2, and 1.5% Al_2O_3 + Fe_2O_3. The deposits also contain a considerable quantity (25 to 50%) of dolomites. In connection with the proposed extension of the Satka magnesite plant, suggestions are made on the utilization of the ore. The average raw magnesite utilized by the plant corresponds to the American standard grade. The construction of an ore concentrating plant makes it possible to obtain up to 40% high-grade ore. The lower grades can be used to obtain metallurgical dolomite and the gases from burning magnesite can be utilized to obtain dry ice. P.P.B.

Working properties of silica mortars. S. S. COLE. *Jour. Amer. Ceram. Soc.*, 18 [2], 61–64 (1935).

Young's modulus of elasticity at several temperatures for some refractories of varying silica content. RAYMOND A. HEINDL AND WILLIAM L. PENDERGAST. *Jour. Research Nat. Bur. Stand.*, 13 [6], 851–62 (1934); R.P. 747. Price 5¢.—Ten brands of fireclay brick covering a wide range in silica content (48 to 82% silica), 2 brands of silica brick (96% silica), and 1 of high alumina (16% silica), were selected and Young's modulus of elasticity was determined for each. The fireclay brick were tested as received from the manufacturer and also after reheating in a laboratory furnace at 1400°C for 5 hr. The effect on the modulus of elasticity of the P.C.E. and porosity and the form or forms of uncombined silica were also studied. After testing the brick at 20, 100, 200, 400, 500, and 600°C, it was found that, with one exception, the modulus of elasticity was affected significantly by the temperature. For 5 brands of fireclay brick the modulus increased gradually between 20 and 500°C and rather abruptly between 500 and 600° C; for 4 other brands of fireclay brick the increase was gradual between 20 and 600°C; for the 2 brands of silica brick the modulus decreased in the range from 20 to 175°C and increased between 175 and 600°C. The decrease of the modulus in the lower temperature range was noted also in highly siliceous fireclay brick. The modulus of the high alumina brick remained constant to 400°C, then increased gradually to 600°C. There is a fairly consistent and approximately linear relation between percentage increase in modulus of elasticity (between room temperature and 600°C) and the silica content, and also the linear thermal expansion, provided the brick are of approximately the same refractoriness and have not been heated sufficiently high to dissolve the silica. On testing 2 silica brick and 3 highly siliceous fireclay brick at temperature intervals of less than 100°C, it was found (with the exception of 1 fireclay brick) that the modulus of elasticity decreased at the approximate temperature of inversion of tridymite and increased at the approximate temperature of inversion of cristobalite, and that, in every case, the inversion of quartz caused an increase. Several specimens were tested before and after having been cooled comparatively slowly from 800°C. Results indicated that the modulus of elasticity was lowered by this treatment. On the other hand when the specimens were air-quenched from 800 and 1000°C, the modulus of elasticity was decreased for the fireclay brick and increased for the silica, and the change in the high alumina brick was practically negligible. Examples of some of the values obtained are as follows: silica brick at 20°C, 1,060,000 lb./in.²; at 200°C, 630,000 lb./in.²; at 600°C, 2,270,000 lb./in.²; approximately 80% alumina brick at 20°C, 2,700,000 and at 600°C, 3,335,000 lb./in.²; fireclay brick ranged from 350,000 to 6,740,000 lb./in.². R.A.H.

BULLETINS

Insulating refractories. G. A. BOLE. *Amer. Refrac. Inst. Tech. Bull.*, No. 51, 8 pp. (1934).—B. discusses the advantages of refractory insulation, methods of manufacture, difficulties of manufacture, properties of insulating refractories, and the use of refractory insulation, and stresses the importance of uniformity of texture and size. A table of properties gives the P.C.E., permeability, thermal conductivity, hot and cold loads, weight, linear shrinkage at 2500 and 2700°F, porosity, modulus of rupture, spall cycle, and service temperature for several samples of insulating refractories. W.E.R.

Reaction temperatures between various types of refractory brick. R. E. BIRCH. *Amer. Refrac. Inst. Tech. Bull.*, No. 52, 11 pp. (1934).—B. presents the results of a study of the reactions between the following refractories at elevated temperatures: silica, fire clay, high alumina, chrome, magnesite (low iron), magnesite (regular), and forsterite. Illustrated. W.E.R.

PATENTS

Porous heat-insulating body. A. P. THURSTON (Babcock & Wilcox Co.). Brit. 419,484, Nov. 28, 1934.

Refractory material. B. J. PATTON. U. S. 1,984,759, Dec. 18, 1934. A refractory material for application to the hot-tops of ingot molds consists of from 8 to 10% chrome ore, 2 to 5% basic slag, 10 to 12% magnesite, 50 to 30% calcined fire clay, 10 to 15% plastic clay, and 20 to 28% common fire clay.

Terra Cotta

Contribution to the scientific study and practice of molding stoneware products. F. CHALAMEL. *Céramique*, **37** [556], 158–67 (1934).—A study of pressing shapes of stoneware showed the following results: (1) Irregular filling of the mold causes variable colorations, poor strength, and irregularity of form. (2) Greater pressure increases strength and regularity, diminishes porosity, and favors the development of sillimanite. Too great pressure leads to cracking. (3) The type of press has little effect. M.H.B.

Scientific manufacture of stoneware tile. I. F. CHALAMEL. *Rev. mat. constr. trav. pub.*, No. 301, pp. 173–75*B* (1934).—A scientific definition of a building product, stoneware tile, and methods of manufacture at the plant are given. M.V.K.

Solving problems in glazing decorative tile. GORDON E. FRENCH. *Ceram. Ind.*, **23** [6], 303 (1934).—By dipping the tile in oil and then applying the regular glaze, a satisfactory product was obtained where brushing the glaze on the untreated tile had resulted in uneven application. A two-tone effect or agate ware was produced by glazing the tile in the regular way, then spraying or dipping the ware in oil, and applying another thin coat of a different colored glaze. A distinct water-marked glaze was produced with a double-glazed body of contrasting glazes. E.J.V.

Spalling of roofing tile caused by frost and sun. JOSEF MATĚJKA. *Stavivo*, p. 275 (1934).—Spalling may be avoided if the clay is excavated by dippers in thin layers, weathered in low heaps, and sufficiently aged. Addition of fine sand to the clay in a ratio determined experimentally is of great advantage. Coarse sand must be crushed or sieved. The body should be worked thoroughly; rolling mills are recommended. The auger-made tile should be aged for some days before they are pressed. R.B.(*R.C.C.S.*)

Stoneware compositions. FRIED BIGOT. *Rev. mat. constr. trav. pub.*, No. 301, pp. 176–78*B* (1934).—Stoneware compositions and their variation and behavior are discussed. M.V.K.

PATENT

Seepage protector for masonry buildings. ALLAN CHENEY. U. S. 1,984,251, Dec. 11, 1934.

Whiteware

Artificial drying of porcelain dishes. A. I. AVGUSTINIK AND S. D. KASHTELYAN. *Keram. i Steklo*, **10** [11], 23–29 (1934).—Experiments made to determine conditions of drying of dishes are described. The results are tabulated, and show that (1) dishes are dried satisfactorily in gypsum molds without artificial moistening of the air; (2) 90° is the maximum temperature of the air in the drier from beginning to end of drying; (3) preheating the molds to 50° has no effect either on the quality of dried and fired ware or on the rate of drying; (4) artificial motion of air accelerates drying. M.V.K.

Deformation of shallow porcelain ware during firing. I. YA. YURCHAK. *Keram. i Steklo*, **10** [10], 6–10 (1934).—The effect of working of porcelain mixes on deformation, the effect of molding on deformation of porcelain dishes, and firing the porcelain are discussed in detail. M.V.K.

Electrostatics. Dielectric substances. I. W. O. SCHUMANN. *Physik*, **2**, 153–66 (1934).—The following properties are reviewed: dielectric constants and dielectric polarization, dielectric losses and absorption, conductivity of insulating liquids and of insulators, space charges, breakdown of gases, solids, and liquids, surface conductivity, sparking, and Lichtenberg patterns, and oscillating crystals. W.M.C.

Handling pottery casting slip. C. D. GRIMWADE. Presented at meeting of Ceramic Society (England), Stoke-on-Trent, Nov., 1934. *Pottery Gas.*, **59** [690], 1464–66 (1934).—G. discusses handling heavy earthenware slip through the various steps taken in producing cast ware. E.J.V.

Methods of conducting electric currents into vacuum containers. H. HANDREK. *Z. tech. Physik*, **15** [11], 494–96 (1934).—Different types of ceramic bodies may be fused together using glass in the same way as solder in metals, the coefficient of expansion of the ceramic bodies varying from 2.5 to 9.0 $\times 10^{-6}$. The most important point of this method is that the thermal expansion of the glass is smaller than that of the ceramic body. Using glass as an intermediate substance will permit the connection of metals to ceramic products. A coating of metal is applied, *e.g.*, to a rod made of ceramic material, and the rod is then connected with a ceramic plate by means of a thin layer of glass. The metal coating will carry the electric current, and the rod will give the strength required. W.M.C.

Porcelain capable of withstanding sharp temperature changes. P. DE GROOTE. *Céramique*, **37** [558], 209–15 (1934).—By adding molten metals such as tin or antimony to porcelain crucibles, P. obtained rapid changes in temperature and found that for the most resistant porcelain, the alkali ratio was 0.1 CaO, 0.5 MgO, 0.4 K_2Na_2O. The best silica-alumina ratio was 11.3 to 3.0. Free silica, added as diatomaceous earth, aided greatly. M.H.B.

Producing lead glazes harmless to health. H. HARKORT. *Sprechsaal*, **67** [41], 621–23; [42], 637–39 (1934).—The harmfulness of lead glazes depends not only on the quantity of uncombined lead oxide, but also on its solubility in the frit. A review of studies and experiments made to determine the effect of PbO in glazes is given, and a testing method, similar to that of testing glass powder, is described by means of which the effect of various components on lead in frits rich in lead was investigated. It was found that lead monosilicates liberate lead to a large extent. The introduction of small amounts of alumina produces an entire or total stabilization of lead; from this point of view alumina is far superior to SiO_2, CaO, and

MgO. Na_2O and B_2O_3, on the other hand, considerably diminish the stability of lead. The quantity of alumina necessary to stabilize lead increases only slightly the fusing temperature of the enamels. The lead silicates found on the market are not stable, but alumina stabilizes the lead present in them. This will permit the use of lead oxide without danger. M.V.K.

Sintered brick for engineering works. ANON. *Sci. et ind.*, p. 214 (May, 1934); abstracted in *Tonind.-Ztg.*, **58** [95], 1166 (1934).—Sintered brick "Vairet Baudet," which are used in France in the acid-treating industry as a material for linings withstanding corrosion, are at present used in the damp tunnels of the Paris subway. M.V.K.

Wedgwood and queen's ware. LAURA LORENSON. *Arts & Dec.*, **41** [6], 58–59 (1934).—Queen's ware, named for Queen Charlotte (Geo. III) in 1765, was evolved by Wedgwood to bridge the gap between the delicate porcelain of the wealthy and the coarse pottery of the poor. It was a cream earthenware with simple designs of ivy, oak, basket, bamboo, etc. The set of 952 pieces made for Catherine II of Russia, with English landscapes as decoration, is famous. Old blue Staffordshire with American scenes followed. Illustrated. E.B.H.

BOOK

Spark Plugs: Their Manufacture and Use in Engines of Internal Combustion. N. E. KOLYUN. State Chem.-Tech. Pub. House, Leningrad, 1932. 136 pp. Price 1.50 R. The different types of ceramic masses for spark-plug insulators are reviewed. The manufacture of talc insulators is described in detail and the manufacture of sillimanite insulators in the U.S. is described briefly. Data are given on the metallic parts of the plugs, their testing, and use. S.I.PERKAL

PATENTS

Ceramic manufacture. J. I. BAHL (R. W. Loichot). U. S. 1,984,108, Dec. 11, 1934.—In a method of making vitreous porcelain products, steps include making a slip of ceramic materials for forming a ceramic body which vitrifies upon firing, passing the slip through a screen having a fineness substantially within the limits 120- to 150-mesh, forming green ware by subsequent processing of the screened slip, and bung-placing the formed green ware for bisque kiln firing.

Earthenware body. I. E. SPROAT (R. T. Vanderbilt Co., Inc.). U. S. 1,984,163, Dec. 11, 1934. Semivitreous earthenware bodies are made from a mixture comprising clay and at least 10% of pyrophyllite.

Method of manufacture of pottery. STEATITE & PORCELAIN PRODUCTS, LTD. (Porzellanfabrik Kahla). Brit. 420,670, Dec. 19, 1934.

Pedestal switch insulator. D. H. ROWLAND (Locke Insulator Corp.). U. S. 1,983,569, Dec. 11, 1934.

Equipment and Apparatus

Air regulator that can be locked. SPRAYCO, INC. *Ind. Finishing*, **10** [12], 38 (1934).—A locking type reducing valve to be used with the B-7 and B-8 air-regulating sets and pressure-feed containers is described. It allows the finishing foreman to establish the proper pressure for best spraying of a given finish and to lock the regulator to deliver only this pressure. Illustrated. J.L.G.

Apparatus for determining characteristics on heating of refractory products. V. BODIN. *Céramique*, **37** [560], 243–51 (1934).—B. describes an electric furnace heated by carbon resistors which may be used for measuring the coefficient of thermal expansion and gives figures obtained with this furnace. M.H.B.

Apparatus for determining volume weight of solids (ceramic bodies). V. N. VELSOVSKIĬ. *Keram. i Steklo*, **10** [11], 20 (1934).—The apparatus is described and results of measurements of six grog-corundum bodies are given in a table. M.V.K.

Apparatus for measuring viscosity of slips and plasticity of mixes. K. ENDELL AND H. FENDIUS. *Chem. Fabrik*, **7** [45–46], 401–403 (1934).—Kaolins, clays, bentonites, and various ceramic mixes, such as porcelain, clayware, and steatite-bentonite mixes, having a varying moisture content were studied by means of these apparatus. Details are given. Illustrated. See also *Ceram. Abs.*, **14** [2], 45 (1935). M.V.K.

Caterpillar belt conveyer for open workings. A. W. MACKENSEN. *Eng. Progress*, **15** [10], 200 (1934).—This traveling belt conveyer has a length of 100 ft. between pulley centers. The belt frame can be rotated 360° on its caterpillar base, and the discharge end can be raised up to 20 ft. above a horizontal position. Both caterpillar track and belt conveyer are driven from the same 10-h.p. Diesel engine which is built into the supporting frame. Illustrated. J.L.G.

Cleaning unit for compressed air. CHARLES C. HENRY. *Enamelist*, **12** [2], 16–17 (1934).—Enamelers seeking control of spray application of enamel slip appreciate the value of a clean compressed-air supply of uniform low humidity. Dry, clean air for spraying and dusting can be obtained by freezing out the water-vapor in the proper manner. A system wherein high-pressure air is bubbled through a chilled solution of calcium chloride brine is described. Illustrated. E.J.V.

Compound mill for cement works. FRIED. KRUPP GRUSONWERK A.-G. *Eng. Progress*, **15** [11], 221–23 (1934).—The Concentra mill described was designed to allow a large weight of grinding bodies to be moved at reduced power input without loss in the impact action indispensable for efficient grinding. The feature which secures this economy is the subdivision of the fine-grinding end into five horizontal, sector-like compartments, each with its proper charge of grinding bodies. The separation of the grinding balls into sections produces torques which partially neutralize each other, producing a net torque to be overcome by the driving force considerably under that of mills of the usual design. The mill can be used for either dry or wet grinding. A comparison of rebuilt and unaltered mills shows that output and quality of the product are not lowered but that the power consumption is

considerably decreased by the new design. The power saving in one case was 23.7% with the same output and in another case, 29.4% with a 10% increase in output. Old type mills can be equipped with the Concentra installation as long as the mill diameter is not under 6 ft. Illustrated. J.L.G.

Consistometer: apparatus for determining plastic properties of glazes, enamels, mixes, and raw materials. GÜNTHER HAMMER. *Sprechsaal*, **67** [43], 653–55; [44], 669–72 (1934).—The apparatus described is used for determining the value of the "limit of elasticity" and the mobility of glazes, enamels, mixes, and raw materials. Both values do not depend on each other and can not be expressed by one value as in measurements of viscosity. The value of the "limit of elasticity" is the power necessary to produce a flow of the liquid out of the capillary. The mobility shows at what rate the liquid flows and is caused by powers which are larger than the value of the "limit of elasticity." Both values characterize glazes, enamels, and mixes. M.V.K.

Electrically driven ore transporter. THOMAS BROADBENT AND SONS, LTD. *Elec. Rev.*, **115** [2976], 789 (1934).—An electrically driven and controlled ore transporter, designed to hoist 12½ tons of ore 80 ft. in the air at a speed of 130 ft./min., to traverse the stock space at 480 ft./min., and to travel longitudinally over 600 ft. of track at 65 ft./min., is used for feeding blast furnaces in Stewarts and Lloyds' steelworks at Corby, England. Illustrated. J.L.G.

Keeping an enamel plant dust-free. ANON. *Ceram. Ind.*, **23** [6], 306 (1934).—The dust-collecting system installed at the Kankakee, Ill., plant of the Florence Stove Co. is described. Illustrated. E.J.V.

Measuring thermal expansion of solid bodies. O. KERSTAN. *Chem. Fabrik*, **7** [49–50], 445–48 (1934); abstracted in *Tonind.-Ztg.*, **58** [94], 1144–45 (1934); *Keram. Rund.*, **42** [48], 595 (1934).—Changes in length are transmitted on a calibrated measuring clock for measuring thermal expansion of solid bodies up to their softening point. This apparatus has considerable advantage over optical instruments. The significance of cooling curves which in some cases may show the formation of new compounds in the body on heating is pointed out. Results on different materials, such as forsterite, magnesite, kaolin, Portland and aluminous cements, calcium silicates, and aluminates, are discussed. The direct practical value of this method was shown in a discussion of results of measurements on teeth fillings which were found unsatisfactory with regard to their expansion due to heat. M.V.K.

Mechanization of the porcelain and faience industries. A. S. BERKMAN. *Keram. i Steklo*, **10** [9], 20–29 (1934).—Various apparatus and machines, such as mills, filter presses, shaping machines, etc., are described. M.V.K.

Method for analyzing structure of clay. P. ARBUZIN. *Azerbaĭdzhanskoe Neftyanoe Khozyaĭstvo*, **13** [11–12], 72–73 (1933); abstracted in *Chem. Zentr.*, ii, 3029 (1934).—The apparatus is described and illustrated. A 2-g. sample is moistened with distilled water and transferred into a 10-liter beaker, water is added, and the liquid is siphoned off after 33 hr. above a height of 10 cm. This decants particles having a diameter below 0.001 mm. and the electrolytes are removed simultaneously. The process is repeated until the water becomes quite clear after the 33-hr. period. The complete removal of the electrolyte is checked by titration. The sample is then heated to 90° and transferred into a settling vessel, whereby the settled fractions are drawn off every 5 min., 15 min., and 1, 4, 8, and 30 hr. into beakers. They are dried and weighed. The settling vessel consists of a cylindrical tube 1100 mm. long which is heated in its upper part to 90°. The preheated clay solution is admitted through the top, it moves downward, and a cylindrical float breaks up the current thus imparting a helical movement. When it meets the cold water below, the movement is checked and separation begins. The heavier ingredients settle first and are removed through a stopcock at the bottom. M.V.K.

Modern preparation of heavy clays. OTTO MANFRED. *Ber. deut. keram. Ges.*, **15** [1], 15–22 (1934).—A review of modern clayworking methods, including the de-airing process, as applied to heavy clay production is presented. E.J.V.

Power used in wire-cut brick machines. ANON. *Brit. Clayworker*, **43** [511], 212 (1934).—A few data are given to show how small variations in water content greatly change the power consumed and how the power is affected by single- or multiple-wing augers and length of collar. R.A.H.

Pump for handling dry material. FULLER CO. *Heating, Piping & Air Conditioning*, **6** [11], 84 (1934).—A pump for handling dry materials is equipped with an integral gearing arrangement which allows the impeller screw to be overhung in the barrel. This provides a clear passage for the material into the conveying line without the need for an offset discharge elbow. An expansion chamber with a flap valve is located at the discharge end of the pump to aid the mixture of compressed air and material to form the "fluent" column of material which will be forced through the conveying line by mechanical pressure. Illustrated. J.L.G.

Pyrometer using only part of the radiation. G. NAESER. *Stahl & Eisen*, **54** [45], 1158–60 (1934).—Temperatures measured by means of ordinary optical pyrometers are uncertain if the emission characteristics of the body observed are unknown; this is the case for metals at high temperatures. Pyrometers measuring brightness are supposed to give more reliable results than those measuring the intensity of radiation. A new optical pyrometer is presented for obtaining simultaneously both color and black body temperatures. Satisfactory results for polished metals have been obtained with this instrument. W.M.C.

Rate of drying in dependence on the mechanical effect on the clay mix. L. A. SHMELEV AND YA. A. USPENSKAYA. *Keram. i Steklo*, **10** [2], 29–34 (1934); abstracted in *Chem. Zentr.*, ii, 2729 (1934).—When pressure is exerted on a body produced from plastic clay, the rate of drying is much more rapid in the direction of the pressure. This was proved on various clays using different methods (rolling, fall or drop of weight, etc.). To obtain this effect, a certain minimum weight is necessary (corresponding to the drop of 10 kg. weight from a height of 15 or 20 cm.). When the surface of a plastic clay body is subjected to a partial pressure and the surface is leveled after this by cutting off the deformed place, a visible depression is formed on drying corresponding to the pressed place. The various local pressures appearing during working and molding of ware

may therefore produce deformation and breaking on drying. M.V.K.

Reducing sandblasting costs. ANON. *Ceram. Ind.*, **24** [1], 30 (1935).—Cast-iron nozzles on the sandblast that were good for only one-half hour of service were replaced with nozzles lined with tungsten carbide. Though nozzle costs were higher, the longer life and saving in labor, power, and abrasive made the investment profitable. The possibility of additional savings by use of the new boron carbide for nozzles is mentioned. Cast-iron bed plates on automatic or continuous blasting tables and entire cabinets on hand-blast operation which were wearing out rapidly were redesigned, and one-half inch of resilient rubber lining on the bed plates and all over the inside of the manual cabinet was installed. After more than a year of steady operation very little wear was shown by the rubber lining. Illustrated. See also "World's—"*Ceram. Abs.*, **14** [2], 46 (1935). E.J.V.

Results of operating driers for an accelerated drying of grog brick at the Gomel glassworks. M. S. KAZANSKIĬ. *Keram. i Steklo*, **10** [10], 10–16 (1934). M.V.K.

Selection of crushing and grinding appliances. B. W. HOLMES. *Mech. World*, **96** [2498], 471–73 (1934).—Preliminary working scale crushing tests are advantageous when special problems have to be considered, either in the crushing of ores or in the preparation of nonmetallic minerals for the market. E.J.V.

Simple way to handle ball-mill jars. GORDON E. FRENCH. *Ceram. Ind.*, **24** [1], 26–27 (1935).—By attaching a metal band around the bottom of the jar and inserting a handle under it and the metal ring around the top, it is possible to handle the jar without pinching the fingers or dropping the jar. Illustrated. E.J.V.

Solving drying problem of fire clay used in producing face brick. ERNEST W. KNAPP. *Brick Clay Rec.*, **85** [5], 170–72 (1934).—As fireclay brick were air-checking badly, a radiated heat type of tunnel drier was remodeled to improve the air circulation. A gathering duct was connected to pressure fans so that heat could be withdrawn from the delivery end of the drier and distributed to other parts to boost temperatures. After making a few other changes in intake, etc., all the trouble was eliminated. E.J.V.

Suspension prevents swinging of load in traveling cranes. FRIED. KRUPP GRUSONWERK A.-G. *Eng. Progress*, **15** [10], 216 (1934).—The load is suspended from a hook placed at the apex of a 4-cable pyramid. Two cables lead directly to 2 drums which are interconnected by bevel gears. The other 2 cables pass from the hook to the drums through sheaves; thus each drum winds 2 cables. Cranes equipped with this device allow the load to oscillate 4 in. or less even with the most abrupt braking. Illustrated. J.L.G.

Transmission by gearing and motors with reducers applied to ceramic machines. PIERRE RENAULT. *Rev. mat. constr. trav. pub.*, No. 299, pp. 149–53*B*; No. 300, pp. 168–69*B*; No. 301, pp. 183–86*B*; No. 302, pp. 200–203*B* (1934).—Illustrated. For previous abstract see *Ceram. Abs.*, **13** [11], 298 (1934). M.V.K.

When should humidity drying be adopted. ANON. *Brit. Clayworker*, **43** [512], 245–46 (1934).—It is assumed that the true meaning of the term "humidity drying" is drying from the commencement with hot air heavily charged but not saturated with moisture. A short discussion on clays easy to dry and clays difficult to dry is given from which it may be stated that controlled humidity drying is essential if the safe drying time of a clay is over 48 hr.; below that figure a simpler practice than controlled humidity may be followed. R.A.H.

BOOK

How to Dry Clay in a Drying Drum. R. KLESPER. State Sci.-Tech. Pub. House of Building and Shipbuilding Ind., Moscow and Leningrad, 1934. 16 pp. Price 25 k. This brochure outlines the principles and significance of drying and the construction of the drum. S.I.PERKAL

PATENTS

Cutting device. G. KOHN AND SON. Czechoslo. P. 9205–31, Dec. 16, 1931; *Stavivo*, p. 128 (1934).—The cutting device moves so that every point describes a circle or similar curve around the extruded clay. R.B.(*R.C.C.S.*)

Cutting device. VLADIMÍR PAVLÍK AND A. THEIMER. Czechoslo. P 9510–30, Dec. 30, 1930; *Stavivo*, p. 129 (1934).—The extruded clay is cut by a thin plate and the brick are automatically shifted to a conveyer belt. R.B.(*R.C.C.S.*)

Machine for manufacturing roofing tile, brick, paving slabs, paving tile, etc. W. G. POWEL. U. S. 1,984,985, Dec. 18, 1934.

Method and apparatus for preventing foaming of liquids. L. O. GUNDERSON (Electro-Chemical Engineering Corp.). U. S. 1,984,210, Dec. 11, 1934. The method of preventing and reducing foam in liquids comprises inserting a pair of metal electrodes in the liquid, imposing an e.m.f. between the electrodes to thereby cause the production of an electrolyte in the liquid, and contacting the foam bubbles with the electrolyte to neutralize the electrical charges contained on the foam bubbles to thereby destroy the foam.

Press for hollow tile closed on five sides. K. JEZEK AND R. JEZEK. Czechoslo. P 9257–31, Dec. 18, 1931; *Stavivo*, p. 9 (1934).—Four molds, which open from three sides and are automatically moved by the pistons, are adjusted on a plate which revolves periodically around the center pillar of the press. R.B.(*R.C.C.S.*)

Pressing of perforated brick. ANON. Czechoslo. P 5186–31, July 3, 1931; *Stavivo*, p. 128 (1934).—The hollow press piston has hollow thorns through which water and air may escape or be evacuated from the brick during the application of the load. R.B.(*R.C.C.S.*)

Unloading device for green brick. K. JEZEK AND R. JEZEK. Czechoslo. P 4978–31, June 25, 1931; *Stavivo*, p. 129 (1934).—While the elevator is moving upward, the frames carrying the green ware are retained and passed to a system of rollers. R.B.(*R.C.C.S.*)

Brick cutting apparatus. F. HOLEČEK. Czechoslo. P 5836–32, Sept. 17, 1932; *Stavivo*, p. 9 (1934).—The clay band extruded from the auger machine is cut by a device which is set into motion by a compressed fluid. R.B.(*R.C.C.S.*)

Kilns, Furnaces, Fuels, and Combustion

Combustion of cut peat in furnaces for firing porcelain. P. PUSAK. *Keram. i Steklo*, **10** [10], 17–19 (1934).—Attempts to use peat as fuel for furnaces for firing porcelain are discussed. Results are tabulated. M.V.K.

Control of draft in continuous ceramic furnaces. R. JACQUEMIN. *Céramique*, **37** [554], 111–13 (1934).—J. shows how pyrometers, CO_2 meters, and anemometers may be used to obtain maximum efficiency from a continuous furnace. M.H.B.

Diffusion combustion. R. F. GRADY. *Ceram. Ind.*, **23** [6], 326–30 (1934).—In the utilization of the diffusion combustion system three serious problems are met, *viz.*, the effects produced by (1) variations in the excess air content of the products of combustion, (2) raw fuel coming in contact with the glazes and enamels, and (3) the combustion of the fuel within close proximity of these glazed surfaces. Any one designing and recommending the use of this type of equipment must recognize these three problems, and their solution must provide means for their nullification if the equipment is to have any general utility in the clay products industry. E.J.V.

Electric firing of white porcelain. H. MASUKOWITZ. *Elektrowärme*, **4** [11], 245–53 (1934).—The advantages of firing in electrically heated tunnel kilns over gas- or coal-fired furnaces are explained with particular reference to white porcelain. They consist principally in (1) reducing considerably the time of firing, (2) decreasing labor cost due to simpler handling, (3) less heating energy on account of smaller volume of tunnel kiln and better ratio of mass of charge to mass of furnace, and (4) freedom from noxious gases which may influence the color. Constructive data on several electric kilns for temperatures up to 1500°C and comparative operating data for coal and electric furnaces are given. The thermal balances of a continuous single and double tunnel kiln of 48 m. length with a maximum temperature of 1300°C are given: current consumption for a charge of 150 kg./m.³ (full load) was 2000 kw.-hr./ton for the single furnace and 730 kw.-hr./ton for the double furnace, and the respective capacities were 2000 and 4000 kg. porcelain in 24 hr. The yearly operating costs for the double furnace with heat recuperation, including amortization, repairs, wages, etc., amounted to 2.50 M per ton. M.H.

Firing ceramic kilns. R. J. CLARK. *Bull. Amer. Ceram. Soc.*, **14** [1], 21–23 (1935).

Heating with gas. R. D. *Verre & Silicates Ind.*, **5** [19], 362–66; [20], 379–83 (1934).—Industrial fuel gases and oils and their combustion were studied. Tables show the composition, and ways are given of calculating the calorific power, amount of air necessary to burn 1 cu. m. of gas, density, theoretical temperature of combustion, volume of combustion products, steam in the smoke, composition of smoke, etc. M.V.K.

Industrial furnaces for fusing magnesite at high temperatures. E. DAMOUR. *Céramique*, **37** [558], 215–16 (1934).—D. describes two gas-fired, high-temperature kilns for fusing magnesite. M.H.B.

Kilns and tunnel kilns for firing brick. B. HELAN. *Stavivo*, p. 154 (1934). R.B.(*R.C.C.S.*)

Luminous flame and diffusion combustion. P. HOPKINSON. *Gas Eng.*, **51** [13], 623–24 (1934).—Luminous flames have great heat radiating power which, in most cases, permits quicker heating, increased production or operation, and lower temperature differentials. The requirements for luminous flame combustion are (1) definite flame length, (2) uniform temperature throughout the length of the flame, (3) maximum heating power or radiation, (4) no contact of the work with air, and (5) correct proportions of gas and air with complete combustion. The diffusion combustion process requires alternate layers of gas and air moving in laminar flow with no turbulent motion. Mixing of the gas and air by diffusion proceeds only at a definite and uniform rate. Diffusion combustion meets the requirements of long flame combustion of maximum heating power (because of maximum concentration of carbon in the flame) and no contact of the work with air. Because of the laminar flow and uniform mixing by diffusion, flame length can be adjusted so that combustion is complete with the correct proportions of gas and air as the gases leave the furnace. E.J.V.

Muffle kiln firing. A. J. BLUME. *Bull. Amer. Ceram. Soc.*, **14** [1], 20–21 (1935).

Periodic furnace with reversible flame. R. WITTE. *Klei*, **26** [8], 67–68 (1934); abstracted in *Chim. & ind.*, **32** [4], 860 (1934).—Illustrated. M.V.K.

Periodic kiln firing. A. J. BLUME. *Bull. Amer. Ceram. Soc.*, **14** [1], 19–20 (1935).

Practical clayworking. XVIII–XIX. ANON. *Brit. Clayworker*, **43** [511], 210–12; [512], 237–40 (1934).—These articles discuss the setting of a zigzag, a Belgian, and a Brown kiln, and the setting of brick on tunnel kiln cars. The firing of intermittent and continuous kilns and the drying of stiff plastic brick by advance heating of newly set chambers are also discussed. For Part XVII see *Ceram. Abs.*, **14** [2], 39 (1935). R.A.H.

Practical tips for firing annular kilns. FR. KOTWALD. *Stavivo*, p. 451 (1933).—Paper for dampers may be partly replaced by filter-cloth; the lower part of the damper is made from cloth, the upper from paper. Such dampers, which are brought in place and removed through the doors, have been in use for two years (about 600 times). The kiln doors are closed with two walls, leaving air as insulation between them. R.B.(*R.C.C.S.*)

Small annular kiln. VLADIMÍR ELIÁŠ. *Stavivo*, p. 191 (1934).—By erecting a center wall in a partial ring kiln of 6 chambers, a small annular kiln with 12 chambers was created. The kiln was 60 m. long and 120 cm. wide and each of the 12 chambers had a capacity of 3800 brick. Fire progress was 5 m. a day for the first ring fired and up to 10 m. a day during the following period. Fuel consumption was 250 kg. coal for 1000 brick. R.B.(*R.C.C.S.*)

Stoker grates for saving fuel in annular kilns. FR. HÁJEK. *Stavivo*, p. 20 (1934).—The grate is formed by a course of 9 brick of which 5 lie across the others. These crossed brick retain the fuel. Above them about 10 courses are laid inclined against the grate. The advantage of this grate is that the benches thus formed do not bear any load. Illustrated. R.B.(*R.C.C.S.*)

Thermal investigations in ceramics. B. HELAN. *Bull. Masaryk Acad. Labor*, No. 43, p. 20 (1934).—In Czecho-

slovakia the center of thermotechnical investigations for ceramics is the Institute for Fuel Economy which coöperates with the Committee on Thermotechnics of the Czechoslovakian Ceramic Society. Record is kept here of the kilns of the brick, lime, pottery, and other industries. For the kiln types most used, best construction and firing process have been evaluated and some of the results of these investigations have been expressed by formulas. Thus the quantity of heat necessary to fire 100 kg. of brick in an annular kiln may be computed from the formula

$$Q_{\text{kg. cal.}} = 425.2\,m - 290\,n - v(639 - t) - \frac{24.100}{q \cdot o \cdot H} S \cdot P$$

where m = % $CaCO_3$, n = % $MgCO_3$, v = % total H_2O in the ware, t = temperature of the ware set in the kiln, q = cross-area of the kiln in m.², o = daily fire progress in meters, H = bulk volume of the setting in kg./m.³, S = inner radiation area in m^2, and P = value of unaccounted for losses (as a rule 200 to 300 kg. cal). From this value Q, the total fuel consumption including stack losses, losses by incomplete combustion, and losses in the ashes, may be computed by the formula, $Q_o = \frac{Q \cdot 100}{100 - k - n - p}$, where k = stack losses in per cent, n = losses by incomplete combustion, and p = losses in the ash in per cent.

R.B.(*R.C.C.S.*)

Wood as fuel for brickworks. O. Skála. *Stavivo*, p. 384 (1933).—In some parts of Czechoslovakia firing wood is cheaper than firing coal. The wood ashes may be used as fertilizer. Content of K_2O is highest in the ashes of oaks, 25 to 35, and beeches, 20 to 30, which also contain the largest quantities of P_2O_5, oaks 12 to 20, beeches 8 to 14%.

R.B.(*R.C.C.S.*)

BOOK

Use of Producer Gas in Furnaces for Firing Refractory and Building Materials. K. I. Sharashkin. State Sci.-Tech. Pub. House of Building and Shipbuilding Ind., Moscow and Leningrad, 1934. 68 pp. Price 1 R, 35 k. This book, which was published after the death of Prof. Sharashkin, who was a member of the American Ceramic Society, is a valuable contribution dealing with the following subjects: (*a*) mixed producer gas from anthracite and its use for firing grog in rotary furnaces, (*b*) combustion of producer gas from anthracite with air enriched with oxygen, (*c*) use of hot blast to introduce increased quantity of water-vapor and increase of calorific value of the gas in a usual gas producer, (*d*) turf and coal producer gas, and (*e*) increase of calorific value of producer gas by the enriched oxygen blast and increased quantity of steam.

S.I.Perkal

PATENTS

Chamber kiln. Jan Kejmar. Czechoslo. P 8217–32, Dec. 31, 1932; *Stavivo*, p. 281 (1934).—The stack has a partition in its lower part which forms flues for the waste gas from two different chambers. R.B.(*R.C.C.S.*)

Construction and building of kilns or muffles used in firing pottery, tile, enameled goods, etc. T. W. Adams. Brit. 420,666, Dec. 19, 1934.

Drying and firing of brick. Fr. Bezunk. Czechslo. P 1058–31, Feb. 9, 1931; *Stavivo*, p. 129 (1934).—This is an addition to Czechoslo. 44,126. A transportable furnace is provided to form a whole with the annular kiln.

R.B.(*R.C.C.S.*)

Flat kiln arches. A. Habla. Czechoslo. P 300–31, Jan. 13, 1931; *Stavivo*, p. 9 (1934).—The flat arch is supported so that it may be lifted if ware is to be set or carried out of the kiln. R.B.(*R.C.C.S.*)

Tunnel kilns. T. W. Shook. Brit. 419,535, Nov. 28, 1934.

Geology

Baryta in France. Anon. *Ind. chimique*, **21** [248], 655 (1934).—A brief review is given of baryta deposits in France. M.V.K.

Bauxite deposits in French East Africa. Anon. *Ind. chimique*, **21** [248], 709 (1934).—The structure of bauxites discovered in the Sudan is more crystalline than that of the French bauxites, some pieces having a vitreous appearance. Samples examined contain from 69 to 75 alumina, 1 to 3.5 silica, 1 to 5 iron oxide, and 0.4 to 3% titanium. The water content is from 20 to 26%. M.V.K.

Beryl-molybdenite deposits of Chaffee County, Colo. Kenneth K. Landes. *Econ. Geol.*, **29** [7], 697–702 (1934).—The geology, mineralogy, and genesis of this beryl deposit are considered. From the evidence, L. believes that quartz veins containing beryl are a link connecting pegmatites with normal quartz veins. J.L.G.

Changes of the exchange capacity of colloidal clays. A. L. S. Bär and H. J. C. Tendeloo. *Rec. trav. chim.*, **53** [11], 1128–32 (1934).—The capacity of clay to exchange ions when shaken with an acid or hydroxide solution is increased or reduced according to the strength with which the H-ions are held by the clay. A theory to explain the phenomenon is derived. M.H.

Classification of clay raw materials. V. Zubchaninov. *Ogneuporui*, **2** [9], 18–22 (1934).—A state standard (OST 5539), "Classification of clay raw materials for the ceramic industry," was introduced Aug. 1, 1933. The clay is classified according to (1) refractoriness (refractory, slow melting, easy melting), (2) presence of impurities, (3) alumina content in fired condition (high basic, basic, semi-acid, acid), (4) grade of plasticity (binding, plastic, nonplastic, stonelike, shales), and (5) type of goods manufactured. Characteristics of each class are given.

P.P.B.

Corundum in the region of the Sludyanski phlogopite deposits (Siberia). A. A. Suloev and A. Ponomarev. *Mineral. Suir'e*, **9** [3], 31–33 (1934). M.V.K.

Fluorite deposits in the eastern Zabaikalie (Siberia). N. S. Lavrovich and I. T. Tarasova. *Mineral. Suir'e*, **9** [3], 16–31 (1934). M.V.K.

Genetic, stratigraphic, and morphological properties of

Ukrainian graphite deposits and their industrial types. I. V. DUBUINA. *Mineral. Suir'e*, **9** [4], 14–22 (1934). M.V.K.

Lusakite, a cobalt-bearing silicate from Northern Rhodesia. A. C. SKERL AND F. A. BANNISTER. *Mineralog. Mag.*, **23** [146], 598–606 (1934).—Lusakite is a cobalt-bearing variety of staurolite from Northern Rhodesia and has been named after the new capital of that colony. The empirical formula is $H_2O{\cdot}4(Fe, Co, Ni, Mg)O{\cdot}9(Al, Fe)_2O_3{\cdot}\cdot 8SiO_2$. Hardness is $7^1/_2$, specific gravity 3.767, n about 1.74. The following features justify the new name: (1) it is the only silicate mineral containing a significant amount of cobalt (CoO, 8.48%); (2) it has an intense cobalt-blue color best seen in thin sections under the microscope; (3) it has strong pleochroism from light cobalt-blue to deep violet-blue; (4) it has been formed by the metasomatic replacement of kyanite. A.K.

Origin of "beef" in shales. W. A. TARR. *Geol. Mag.*, **70**, 289–94 (1933); *Sci. Progress*, **29**, 297 (1934).—"Beef" (fibrous calcite) is due to the leaching of $CaCO_3$ from marl by water and its subsequent deposition. The thin paper-shales which intervene between the layers of "beef" represent concentrations of the original clay of the marls. H.H.S.

Petrology of kaolin deposits near Anna, Ill. RALPH E. GRIM. *Econ. Geol.*, **29** [7], 659–70 (1934).—The petrology of the white clays located near Anna in Union County, Ill., is considered. They have been found valuable as fire clays and as bleaching agents or decolorizers. The chief mineral constituent is kaolinite. This makes their bleaching action noteworthy since most fuller's earth consists not of kaolinite but chiefly of montmorillonite. One map. J.L.G.

Quartz, feldspar, and clay as industrial materials of chemical industry. W. MIEHR. *Chem. Fabrik*, **7** [45–46], 397–401 (1934).—A review is given of (1) deposits of quartz, feldspar, clay, and kaolin, (2) their properties, (3) working, and (4) applications in chemical industry. M.V.K.

Studies on zeolites. VII. "Clinoptilolite," a silica-rich variety of heulandite. MAX H. HEY AND F. A. BANNISTER. *Mineralog. Mag.*, **23** [145], 556–59 (1934).—Based mainly on an X-ray study of single crystals, the authors conclude that there can be no doubt that "clinoptilolite" is merely a high-silica heulandite. Heulandite shows marked variations in composition, the silica content ranging from 53 to 61%; the clinoptilolites show 66 and 64% silica in the two published analyses. The oxygen content for both heulandite and clinoptilolite is 72 atoms per unit cell. The unit cell formula of heulandite appears from the data so far available to be essentially $Na_x{\cdot}Ca_y{\cdot}Al_{x+2y}{\cdot}Si_{36-(x+2y)}{\cdot}O_{72}{\cdot}24H_2O$, where $(x + y)$, the number of cations per unit cell, is variable, ranging from 4 to 6 and $(x + 2y)$, the number of aluminium atoms per unit cell, ranges from 8 to 10 in most heulandites. In the clinoptilolites, the aluminium content falls as low as 6 atoms per unit cell while the cation content is within the above range of 4 to 6 atoms. The water content in both clinoptilolites and ordinary heulandite generally falls considerably below 24 mol. per unit cell. This is probably due to the high vapor pressure of the quasi-saturated zeolite at room temperatures. Similar behavior has been observed in the case of edingtonite. For Part VI see *Ceram. Abs.*, **13** [7], 191 (1934). A.K.

Synthetic replacements in "open space." C. SCHOUTEN. *Econ. Geol.*, **29** [7], 611–58 (1934).—In an effort to develop a method of recognizing and classifying the results of natural mineral replacements, S. brought about a series of artificial replacements by immersing the material to be replaced in a strong solution of the proper salt. The method was successful in many cases. Photomicrographs of replaced surfaces are shown. J.L.G.

Technological study of corundum rocks of the Chainitzkil deposits in South Yakutiya. A. G. ELISEEV, K. YU. KVOKOB, AND K. N. OZEROV. *Mineral. Suir'e*, **9** [6], 13–20 (1934).—After a discussion of corundum deposits in South Yakutiya, Siberia, attempts to use this corundum as an abrasive are described. M.V.K.

Thermal expansion of plagioclase. SHUKUSUKE KOZU AND JUNICHI UEDA. *Proc. Imp. Acad.* [Tokio], **9**, 262–64 (1933); abstracted in *Chem. Zentr.*, **ii**, 1754 (1934).—The thermal expansion curves of plagioclase do not show any break as in feldspars rich in potassium. Albite has the largest increase in volume (2.75% at 1000°); oligoclase increases 1.96% and anorthite, 1.45% at 1000°. "Adular" from St. Gotthard expands less than albite (2.21%), while the moonstone of Ceylon increases most in volume (3.39% at 1000°). M.V.K.

Utilization of different rocks by melting. V. CHARRIN, *Verre & Silicates Ind.*, **5** [21], 402–403 (1934).—The properties and application of fused quartz and fused basalt and a discussion of the trachyte, "domite," of Auvergne are given. M.V.K.

BOOKS

Applied Geophysics in the Search for Minerals. A. S. EVE AND D. A. KEYS. 2d ed. xi + 296 pp. Univ. Press, Cambridge, 1933. Price 16s net. Briefly reviewed in *Nature*, **134** [3390], 618 (1934).—The book is a manual for the use of mining engineers, geologists, and others with an economic interest in prospecting. J.L.G.

Feldspar. H. O. ROGERS AND R. W. METCALF. Reprint from U. S. Bur. Mines Minerals Yearbook (*Ceram. Abs.*, **14** [2], 51 (1935)). 8 pp. Price 5¢.

Flora of Pottsville age from the Mosquito Range, Colo. C. B. READ. *Geol. Surv. Prof. Paper*, 185-*D*. 17 pp. Price 10¢. R. describes a fossil flora comprising seventeen species from the lower part of the Weber formation of the Mosquito Range. These plants show that the age of the containing beds is early Pennsylvanian and indicate a correlation with the Pottsville formation of the eastern U. S. Three of the species are new, and one of them represents a new genus. R.A.H.

Geometrical methods of a quantitative mineralogical analysis of rocks (Geometricheskikh metodakh kolichestvennogo mineralogicheskogo analiza gornuikh porod). A. A. GLAGOLEV. Gorgeoneftizdat, Moscow, Leningrad, 1933. 46 pp. Price 1 R, 50 k. Reviewed in *Mineral. Suir'e*, **9** [4], 48–49 (1934). M.V.K.

Geophysical prospecting abstracts. F. W. LEE. *Bur. Mines Periodical Service Rept.*, G. A. 66, 20 pp. Price 10¢. See also *Ceram. Abs.*, **14** [2], 50 (1935). R.A.H.

Manual of Mineral Deposits. Part I. Deposits of Mineral Raw Materials. P. M. TATARINOV, K. N. OZEROV,

M. A. IVANOV, S. F. MALIAVKIN, AND G. O. SMOLKO. Edited by P. M. Tatarinov. ONTI, Moscow, Leningrad, and Novosibirsk, 1934. 600 pp. Data are given on the principal world deposits of the following minerals: pegmatites, feldspar, mica, apatite, corundum, graphite, granite, andalusite, sillimanite, kyanite and dumortierite, asbestos, talc, and soapstone, magnesite, alunite, phosphate rock, sulfur, salt, iodine and bromine, and bauxite. P.P.B.

Petrography of sedimentary rocks (Petrografiya osadochnuikh pozod). M. S. SHVETZOV. Gorgeoneftizdat, Moscow, Leningrad, 1934. 374 pp., 46 illustrations. Price 5 R, 40 k. Reviewed in *Mineral. Suir'e*, 9 [4], 45–48 (1934). M.V.K.

Talc and ground soapstone. ALDEN H. EMERY AND B. H. STODDARD. Reprint from U. S. Bur. Mines Minerals Yearbook (*Ceram. Abs.*, **14** [2], 51 (1935)). 9 pp. Price 5¢. R.A.H.

Chemistry and Physics

Bleaching kaolin. E. GALABUTSKAYA AND R. GOVOROVA. *Mineral. Suir'e*, 9 [4], 27–32 (1934).—Kaolins colored strongly by iron oxides can be bleached by treating them with Na_2SO_4 which removes only the iron present in kaolin. Because of a decrease in the amount of Fe_2O_3, some physico-mechanical properties of the kaolins, such as color, shrinkage, water absorption, and mechanical strength, change. M.V.K.

Dielectric losses in crystals. N. BOGORODIZKY AND V. MALYSCHEV. *Arch. Elektrotech.*, **28** [10], 644–53 (1934).—Dielectric losses were determined for rock salt, mica-muscovite, gypsum, talc, and for quartz both parallel and perpendicular to the optic axis. The dielectric losses in these crystals are explained by the classical theory. The conductivity of rock salt at high and low frequencies coincides with that for direct current. Mica shows identical losses for alternating current and direct current at high temperatures, but varying losses at low temperatures. Quartz parallel to the optic axis and pure amorphous quartz show identical data for a.c. and d.c., whereas quartz perpendicular to the optic axis shows different values. W.M.C.

Effect of adsorption films of colloidal hydroxides of trivalent metals on mineral suspensions. L. V. LYUTIN AND G. V. ZAKHAROVA. *Mineral. Suir'e*, 9 [5], 63–70 (1934).—The effect of sols of hydroxides of trivalent metals on suspensions of graphite, barium, quartz, and glass was studied. It was found that sols of these metals are adsorbed on the surface of suspension particles and form films. Sols of trivalent metals can be used as stabilizers and protective colloids when obtaining highly dispersed suspensions with a wet treatment of raw materials. M.V.K.

Flame analysis for testing materials. F. WAIBEL. *Z. tech. Physik*, **15** [11], 454–56 (1934). W.M.C.

Fluorine determination in silicate rocks, also applicable to waters, etc. OSKAR HACKL. *Z. anal. Chem.*, **97** [7–8], 254–58 (1934).—After a review of the work on fluorine determination, the following methods are described: (1) the precipitation as triphenyl-tin-fluoride of N. Allen and N. H. Furman, which unfortunately requires a rather difficultly prepared reagent and also requires that a determination of the proportions in the silicate rock analysis be made; (2) the method of H. H. Willard and O. B. Winter with zirconium-alizarin-thorium nitrate, with which amounts down to 0.15 mg. and even 0.02 and up of fluorine can be determined. A disadvantage lies in the necessarily standardized solutions which are rational for serial determinations, but not for occasional individual determinations. It is necessary to remove the residue following the volatilization of fluorine as fluosilicic acid, which distillation is injured by silica gel and aluminium when these two hindering components appear as chief constituents in the silicate rock analysis. E.J.V.

Heat capacity of mineral raw materials. A. BAZILEVICH. *Mineral. Suir'e*, 9 [3], 48–50 (1934).—The average heat capacity of various mineral raw materials was measured. The Prosyanskiĭ kaolin undergoes a strong endothermic reaction at 542° which uses 210 cal. for 1 g. of the prime weight. At 942°, an exothermic reaction yielding 30 cal./g. occurs in consequence of which the sample is heated by 115°. Chassov Jar clay has a weak endothermic reaction between 200 and 300° and a larger one between 550 and 600°. The total of endothermic reactions is 175 cal./g. No exothermic reactions were observed. Inzenskiĭ diatomite has an endothermic reaction beginning at 400° (150 cal./g). Khalilovskiĭ talc has two maxima of heat of absorption: the first is a weak one between 600 and 700°, and the second is larger and occurs at 900°. The total is 92 cal./g. Ilmenskiĭ zircon does not undergo thermal reactions between 20 and 1050°. Polevskiĭ calcite has a sharp endothermic reaction at 880° the value of which amounts to 472 cal./g. Satkinskiĭ magnesite undergoes a strong endothermic reaction between 500 and 650° amounting to 356 cal./g. Khalilovskiĭ chromite has a considerable loss on ignition because of the presence of serpentine and an endothermic reaction occurring between 600 and 700°; its value amounts to 40 cal./g. M.V.K.

Indirect method for potentiometric determination of cobalt. P. SPACU. *Z. anal. Chem.*, **97** [5–6], 192–95 (1934).—The cobalt salt solution (30 cc. of 0.01 m. $CoSO_4$ solution) is mixed in a 100 cc. graduated flask with a measured volume (20 cc.) of a known 0.1 m. KSCN solution (so that SCN' is in excess) and 1 cc. pyridine. After the settling of the precipitate of $CoPy_4(SCN)_2$ that forms, the flask is filled to the mark with distilled water and the whole is shaken well and filtered through a dry quantitative filter. Then taking 50 cc. of the filtrate, the excess pyridine in the solution is neutralized with nitric acid in the presence of methyl orange. To it is added 30 to 40 cc. of water and the excess of KSCN is titrated with 0.1 m. $AgNO_3$ solution by the Klassen potentiometric method. The above-mentioned reaction serves for the determination of cobalt in the solution used. E.J.V.

Methods for determining fluorine in fluorspar. I. TANANAEV. *Z. anal. Chem.*, **99** [1–2], 21–26 (1934).—A

method for the determination of fluorine in fluorspar is described in which PbFCl is precipitated and the excess of chlorine ion in the filtrate is titrated. The advantages of the method are that the fluorine is precipitated from the solution without previous removal of the calcium, so that the time for a determination is reduced to 1 hr., and at the same time the sources of error connected with the incomplete leaching out of fluorine from the melt are eliminated. A new modification of the distillation method of determining fluorine as fluosilicic acid is also described. E.J.V.

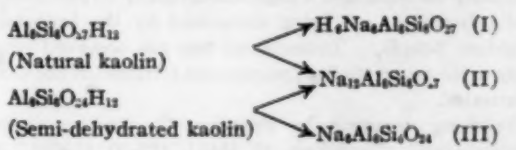
Physicochemical transformations of kaolins and clays on heating. S. V. POTAPENKO. *Mineral. Suir'e*, **9** [6], 20–23 (1934).—The dehydration of kaolin on heating is accompanied by a disintegration of kaolinite ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$) into silica and alumina which remain in a free state up to 1150 or 1200° and form mullite above 1200°. Thermal analysis of kaolin when heated to 1300° shows four thermal effects: (1) small endothermic effect occurring at 100 to 110° and accompanied by the removal of hygroscopical water; (2) large endothermic effect at 560 to 580° accompanied by a disintegration of kaolinite into silica, alumina, and water; (3) large exothermic effect beginning at 950° with a conversion of free alumina from amorphous state into the crystalline; and (4) small exothermic effect at 1180 to 1250° with a formation of mullite. The increase in volume (lowering of shrinkage) and decrease of specific gravity after firing above 1300 or 1400° depend on the transformation of free silica into cristobalite. The transformation of refractory clays may proceed in a different way, but it ultimately leads to the formation of mullite. M.V.K.

Vitreous phase in vitrified ceramic materials. B. LONG. *Céramique*, **37** [559], 227–32 (1934).—L. offers figures on the expansion and fluidity of sillimanite-glass and zircon-glass mixtures. Several representative curves are given. See *Ceram. Abs.*, **13** [6], 161 (1934); **14** [1], 24 (1935). M.H.B.

Separation of magnesia from dolomite. C. R. PLATZMANN. *Chem.-Ztg.*, **58** [84], 851–52 (1934).—Various methods suggested for separating magnesia from dolomite are discussed. M.V.K.

Spectral analysis as tool for testing and ordering materials. W. GERLACH. *Z. tech. Physik*, **15** [11], 451–53 (1934). W.M.C.

Structure of kaolin. Stability of the aluminium silicate nucleus in kaolin and its derivatives. M. DOMINIKIEWICZ. *Bull. trav. dépt. chim. inst. hyg. état* [Warsaw], No. 6, pp. 105–106 (1934*R*); abstracted in *Sprechsaal*, **67** [48], 734 (1934).—The following reactions of kaolin were studied:



The aluminium silicate nucleus remains unchanged. While (I) is obtainable in a hydrothermal way only, (II) is obtainable in a thermal way only; (II) hydrolizes easier and (I) is actually formed from (II) under the action of water at 180 or 190°. When heating with an $Ag \cdot NO_3$ solution in a reflux condenser, Na is entirely replaced in (I) and (II) by Ag, and a white Ag-hydrokaolinate (IV) and an olive-brown di-Ag-kaolinate (V) are formed. In (III), Ag does not replace Na. The corresponding K compound ($4H_8K_8Al_8Si_8O_{37} \cdot 3H_2O$) is formed when boiling (IV) with a KCl solution. Under the action of NH_4Cl on (IV), $H_{10}(NH_4)_2 \cdot Al_8Si_8O_{37}$ is obtained, which changes into semi-dehydrated kaolin on calcining. (V) forms an analogous compound ($4H_{10}[NH_4]_2 \cdot Al_8O_{37} \cdot 3H_2O$) with a similar reaction. When boiling (V) with a NaCl solution, 3/4 Ag are split off, 1/2 is replaced by Na, and 1/4 by H; $4H_3Ag_5Na_4Al_8Si_8O_{37} \cdot 3H_2O$ is obtained. M.V.K.

System Na_2O–B_2O_3. I. Preparation of crystalline B_2O_3 and some of its physical properties. S. S. COLE AND N. W. TAYLOR. *Jour. Amer. Ceram. Soc.*, **18** [2], 55–58 (1935).

System R_2O–B_2O_3. II. Properties of anhydrous and hydrated metaborates of sodium and potassium. S. S. COLE, S. R. SCHOLES, AND C. R. AMBERG. *Jour. Amer. Ceram. Soc.*, **18** [2], 58–61 (1935).

System, silicon–aluminum. II. Reaction of kaolinite and a new group of heterosilicates. O. REBUFFAT. *Giorn. chim. ind. applicata*, **16** [9], 433–35 (1934).—Experiments are described which demonstrate that it is possible to obtain twenty new Al-Si compounds. The various compositions and melting points are given and reactions between tridymite and some of the new compounds are described. For Part I see *Ceram. Abs.*, **14** [1], 23 (1935). M.H.

Why does water moisten the glass? M. HOLDERER. *Compt. rend.*, **199** [20], 1046 (1934).—The reason that water moistens the surface of glass is seen in the affinity of the O in H_2O to the O contained in the glass. Hg does not moisten glass as no O is in it, but a trace of O on the surface of Hg suffices to make it moisten the glass in places. The O of the oxide sends two valencies to the glass and the others to the Hg. M.H.

X-rays for use in testing materials. R. GLOCKER. *Z. tech. Physik*, **15** [11], 421–29 (1934).—This is a review of modern X-ray methods used in radiographs of various materials, in analyses by means of diffraction patterns, and in determinations of strain in metals. W.M.C.

BOOKS

Chemistry of Solids. CECIL H. DESCH. 213 pp., 55 figs. Cornell Univ. Press, Ithaca, N. Y., 1934. $2.50. Briefly reviewed in *Econ. Geol.*, **29** [7], 707 (1934).—Phases of crystallography, metallurgy, microchemistry, and physical chemistry are combined in this work which will prove valuable to chemists, geologists, and others. J.L.G.

Crystalline State. Vol. I. General Survey. W. L. BRAGG. Edited by William Bragg and W. L. Bragg. xiv + 352 pp., 32 plates. G. Bell & Sons, Ltd., 1933. Price 26s. Reviewed in *Nature*, **134** [3383], 303–305 (1934).—General properties of the crystalline state are described and the importance of the atomic pattern or lattice structure is stressed. Diffraction caused by such a lattice is considered. The Laue method of X-ray analysis, the ionization spectrometer method, the rotation photograph method, and the powder method are discussed and their application to different types of samples is considered. The crystal analyses of samples of KCl, NaCl, ZnS, diamond, CaF_2, and FeS_2 are explained step by step. Crystal symmetry, structure analysis, interaction of atomic

forces, influence of size and orientation of crystalline particles (crystal texture), X-ray optics, diffraction of electrons, the application of X-rays to problems of pure and applied science, and the history of X-ray methods receive clear and careful consideration. Six appendices of data of value in the use of X-ray methods are included.

J.L.G.

PATENTS

Process of recovering beryllium oxide. K. A. FERKEL AND A. I. ELLIS (Beryllium Corp.). U. S. 1,986,567, Jan. 1, 1934. The process of recovering beryllium oxide from siliceous ores containing beryllium and aluminum together with a heavy metal comprises treating the ore to convert the beryllium and aluminum into acid soluble compounds, adding acid to form soluble beryllium and aluminum salts of such acid, evaporating to dehydrate and render insoluble the silica present, leaching with water to extract the soluble salts including any soluble compound of the heavy metal present, adding caustic soda to excess to convert the beryllium and aluminum salts to sodium berylate and sodium aluminate and to convert any heavy metal present to its insoluble oxide or hydroxide, separating from the solution insoluble material including any such insoluble heavy metal oxide or hydroxide, adding water to the solution and heating it to cause precipitation of beryllium hydroxide, separating the precipitate and converting it to beryllium oxide.

Sodium barium aluminate and process of making. E. E. FISHER (National Pigments & Chemical Co.). U. S. 1,985,318, Dec. 25, 1934. (1) A composition which has been fused comprises a barium aluminate and sodium aluminate in intimate association resulting from concurrent production. (2) In the art of making soluble barium compounds, the process comprises mixing a barium salt with a sodium salt and alumina substantially in molecular proportions such as to yield a product having the formula ($3BaO \cdot Al_2O_3$) and a product having the formula ($Na_2O \cdot Al_2O_3$), and heating the mixture to expel the acid radicals from the salts and concurrently produce the products in intimate mixture.

General

Boiler feed and its influence on economy. CHAS. F. WADE. *Brit. Clayworker*, **43** [512], 241–42 (1934).—Boiler efficiency is affected appreciably by such factors as temperature, rate of feed relative to the steam demand, circulation in the boiler, etc. W. discusses importance of insulation of hot water returns, control of the rate of water feed, automatic water-feed regulators, optimum temperature of feed water, and importance of free water circulation in boilers. R.A.H.

International standardization of the term "ceramics" and ceramic terms. S. I. PERKAL. *Bull. Amer. Ceram. Soc.*, **14** [1], 23 (1935).

Material testing in ceramics. HANS HECHT. *Ber. deut. keram. Ges.*, **15** [1], 22–36 (1934).—A thorough review of methods for testing ceramic raw materials and finished products is presented. Bibliography. E.J.V.

Petrurgical plant for Isachkovskiĭ diabase and ware produced from fused diabase. G. M. KOROVNICHENKO. *Mineral. Suir'e*, 9 [5], 57–63 (1934).—After a short discussion of Isachkovskiĭ diabase deposits, experiments with fusing and casting diabase ware are described. Ware such as cubes, electric insulators, brick, tile, tubes, etc., manufactured from fused diabase, possess a completely crystalline structure, a high strength, acid stability, refractoriness, and other properties after suitable thermal treatment. Data are given. M.V.K.

Quality measured in thousandths of an inch. ANON. *Ceram. Ind.*, **23** [6], 304–305 (1934).—The Standard & Specialty Porcelain Works, Sun Prairie, Wis., is producing 550 kinds of products for the electrical, textile, gas-heating, and other industries, each product demanding special care in processing because of the rigid specifications governing them. A description of the care taken in preparing the raw body for pressing is given. As periodic kiln firing gave an average of 10 to 15% spoilage, a tunnel kiln was installed and seconds were reduced to an average of 3%. A full description of the plant set-up and kiln is given. Illustrated. E.J.V.

Silicosis. W. R. JONES. *Iron Coal Trades Rev.*, **128** [3442], 294–95 (1934). **Discussion.** *Ibid.*, **128** [3443], 331; [3447], 497; [3448], 535 (1934).—In a large number of silicotic lungs examined, a dust consisting of minute acicular fibers of sericite was found. Therefore J. submits that it is mainly the fibrous minerals, sericite, sillimanite, tremolite, etc. (or a fibrous form of free silica as in chert or of a fibrous rock as in pumice) present in aggregates which, during the impact of drilling, blasting, or crushing, become freed in the atmosphere as individual fibers, that enable sufficient material in course of time to enter the lungs to cause silicosis. W.E.R.

Silicosis, a study of 106 pottery workers. PAUL A. QUAINTANCE. *Amer. Jour. Pub. Health*, **24** [12], 1244–51 (1934).—Fifty-eight cases are reported from the pottery industry in which the concentration of dust is low; silicosis develops slowly and symptoms are latent and appear many years after physical and X-ray signs of silicosis are demonstrable. In advanced silicosis, total and permanent disability for work and a high susceptibility to pneumonia and tuberculosis are being recognized by the Industrial Accident Boards. Tuberculosis was not observed clinically in the group studied; pneumonia terminated one case. Illustrated. E.J.V.

Teaching ceramics in France. G. LECHEVALLIER-CHEVIGNARD. *Céramique*, **37** [555], 125–31 (1934).—L. outlines the history and organization of ceramic education in France. M.H.B.